Architectural Publication Society. Part I. New Volume.—The part now out is an earnest for the volume of 1849-50, showing that good faith will be kept with the supporters of the Society, while it is announced that a second part is in progress. Among the present subjects of illustration are Catacomb, Corbel, Façade, Furniture, Loggia, Screenwall, Staircase, and Tomb, and a coloured plate is promised with the next part. Many examples are given which will be new to the profession.

On Copyright in Design. By Thomas Turner, Esq., of the Middle Temple.—A work which contains much useful matter on a subject now of great interest to the mechanical classes. We would suggest to the author, that in a second edition an index should be added.

Counsel to Inventors of Improvements in the Useful Arts. By Thomas Turner, Esq., of the Middle Temple.—A popular and amusing dissertation on patents and inventions, with many anecdotes.

Buildings and Monuments. By G. Godwin, F.S.A. Part VI.—We have already spoken so frequently in commendation of this cheap and useful work, that we can do nothing more than record its progress.

Hints on the Valuation of Ecclesiastical Property.—A useful little work, explaining the nature of ecclesiastical property, the valuation of which is necessarily not understood by the profession generally.

ON FURNITURE AS A BRANCH OF DECORATIVE DESIGN.

[FIRST ARTICLE.]

Were the matter itself regarded and treated as one of no importance—were we content to abide by usefulness and convenience, without aiming at anything further, we could not expect that any study should be given to the subject of Furniture, as a branch, though perhaps a subordinate one, of artistic design; but as precisely the reverse is the fact, and as next to architecture furniture affords opportunities for exercising taste and invention, and that not only occasionally but daily, it is somewhat surprising that nothing whatever has been written concerning it, beyond a few random and incidental remarks. Neither Hope nor Percier have entered into the subject, or attempted to lay down any guiding principles of correct taste; but have contented themselves with merely exhibiting their designs, and prefacing them by some desultory general observations. Tasteful, too, as their designs are upon the whole, they betray not a few incongruities, and, in some instances, a most disagreeable mixture of excessive plainness with excess of ornament. Speaking generally, furniture-design may be said to be made altogether a matter of empirical practice. We frequently see very great skill of workmanship and great beauty of material expended upon objects of the kind, with scarcely any attention to elegance of form; the last being in some instances completely marred by ornament that serves only to enhance both labour and cost. With both the producers and the purchasers of furniture, sound good taste is but a very secondary consideration; while the former look chiefly—and naturally enough too—to their immediate interest as manufacturers and tradesmen, the others consult only fashion, or are guided by individual fancy alone. Neither party is capable of properly directing or correcting the taste of the other; nor is it strange that such should be the case, when furniture is looked upon as having nothing to do with art, or art with it, but as being altogether lawless, and when with regard to "taste" means little more than "whim."

Some there are who are either quite indifferent to everything connected with *ameublement*—as was, for instance, Goethe, although otherwise by no means destitute of *formen-sinn* and æsthetic sensibility—or else affect to despise all such matters as partaking of frivolity and effeminacy; and we may very safely leave them to enjoy their philosophical contempt, there being no danger whatever of its becoming an epidemic. We ourselves adopt Mr. Fergusson's philosophy: "At present," says that able writer and original thinker, "the art (viz. of furniture) is entirely in the hands of shopkeepers, and, of course, has no right to the rank which I have assigned it. Yet there are instances even in this country, and at the present day, where one presiding mind, under the guidance of good taste, has taken the requisite trouble to elaborate the whole design, and where the carpets, curtains, and furniture have been grouped into a whole of no small beauty and elegance. It is not a high art, but it is one capable of a very considerable degree of refinement; and from the circumstance of its being an absolutely necessary one, and its objects always present, it is capable of exercising no small degree of influence on the tone of the mind, according as refinement or vulgarity may predominate,"—which doctrine, we may observe, has been successfully carried out practically by the writer himself in his own tastefully fitted-up and embellished residence.

After all, it will perhaps be said, all objects of the kind soon grow familiar to the eye, and cease to afford any positive enjoyment. The charm of novelty, of course, wears away, the first emotions of vivid delight gradually sober down; but so is it with a prospect, however beautiful, which is daily viewed from one's windows. In the one case as in the other, the charm of novelty is succeeded by the more quiet and silent gratification of habit. An atmosphere of taste and artistic beauty is produced, whose cheering influence is permanently felt, although it is what is unnoticed, and also what hardly admits of being explained. All, indeed, that recommends itself by the mere vogue of fashion, or by glare, glitter, and showiness alone, soon palls upon the eye,—we become cloyed with it, and wish for change. Really good taste, on the contrary, carries with it a permanent charm, and a nameless fascination. Such taste, too, is, *cæteris paribus*, the cheapest and most economical of any—albeit, not very cheap in one sense, since it is not to be bought; there is no mart where it is sold ready-made. Still, it is in itself the most economical, because capable of producing effect with the minimum of means—never wasting any of the means at its command; and also because it never stales, but possesses an endurable power of charming. Independent of mere fashion from the first, it never becomes "old-fashioned," like that which, destitute of intrinsic artistic merit, recommends itself only by being in the passing mode of the day, admired for a brief while, and then not only discarded, but perhaps held up to derision and ridicule. Time settles a good many questions of taste; notwithstanding which, there is just now a most unfortunate disposition to revert to much false and even depraved taste which, whether on that account, or merely owing to the changes of fashion, had very deservedly been exploded, yet is now again brought into vogue by the prestige of names—Renaissance, Elizabethan, Louis Quatorze, &c.—and in consequence of the demand for novelty, while our designers and manufacturers, unable to produce it—incapable of extracting what is good in former styles of decorative art from their mere dross and rubbish—merely serve them up again, with less of invention and skill than a cook shows by converting the remains of a cold joint into a savoury hash.

Good taste, again, is the most economical, because it works according to the means and resources at its command; making the most of the means afforded it; never attempting more than can be carried out consistently by them. It knows precisely how far it can go without breaking down; it never errs on the side of too much; still less does it jumble the "too much" and the "too little" together, as is frequently done; and if but little can be accomplished, it will make that little appear to be the "quite enough." Wasting nothing, it allows nothing to appear wanting; but working with well-understood purpose, and putting everything in its proper place, it makes every stroke tell. To all that it does we may apply Pope's well known line:—

"And not a vanity is given in vain:"

taking vanity in the sense of ornament, which is more than can be generally said of the taste of "decorators" and their employers; for theirs is apt to remind us too forcibly of the "all is vanity." With them, elaboration and ornament are everything—at once their *forte* and their foible—their strength and their weakness; while of character and expression, artistic effect and *ensemble*, they take no account. They are in decoration what Denner was in painting—we marvel at the pains-taking hand, but we miss the artist-mind. Such minikin taste seems to be just now gaining vogue; for although decorative art and ornamental design are much talked about, they seem to be very imperfectly understood, and to be taken up on wrong principles, if upon any principles at all.

Now, in our opinion, ornamental design means a very great deal more than the merely designing ornament, details, and patterns, which are afterwards applied at random to anything and everything indiscriminately. Our designers and artisans seem to endeavour to conceal their poverty of invention, crudeness of taste, and inability to produce graceful and fresh combinations, by a profusion of unmeaning, fantastic ornament, which rather encumbers and disguises than embellishes, though it very seldom conceals the insipidity or else the positive ugliness of the article to which it is applied. Most of the designs for furniture and manufactures

which have appeared in the *Art Journal*, are open to such censure; and even the best of them show very questionable and so-so-ish taste, and borrowed ideas—borrowed, moreover, from the worst school, that of the so-called Rococo; wild and capricious, yet imbecile and dull. Instead of grace, or any approach to it, we have only grotesqueness and grimace—incoherent shapes tortured into such deformity that only the intrinsic beauty of material and colour, together with the fictitious value of cost—which is often in direct inverse ratio to æsthetic value—can render them endurable to the eye. No doubt very serviceable lessons may be derived from corrupt modes and fashions of design, because from them we may learn what are the faults and errors which are studiously to be shunned.

In all those modes which, however they may be distinguished from each other, come under the general denomination of Rococo, the taste shown is so very coarse, and the faults so gross, that it might be thought the slightest degree of æsthetic feeling would deter from re-adopting them at the present day, *after* we have become acquainted with specimens of both classic and mediæval design, which are infinitely superior. Such strange perversity is to be accounted for only as verifying the remark, that

"L'ennui du beau améne le gout du laid."

The perversity becomes all the greater because accompanied by inconsistency: with us the preposterous taste which there is now an unfortunate disposition to revive, is no longer costume, but mere masquerade, put on at the bidding of fashion. So long as it was costume, it extended to everything alike—not only to furniture and interior decoration, but to architecture itself; to equipages and carriages, to dress, and to gardening. The human form was disfigured by the most extravagant and absurd attire; and nature itself metamorphosed, as far as it could be, by the operation of the shears, and the application of the line and compasses. In all things alike, the unnatural was mistaken for the artistic; the only difference being, that while the natural was made to imitate the artificial, the artificial was made to imitate the natural. Execrable as such false taste must be pronounced, there were excuses for it in its own day, which no longer exist; because then, instead of being taken up for the nonce, ready made, it grew up conformably to circumstances. Clumsy and barbarous as it was, it was not a *relapse* into what had been discarded; which kind of falling back upon what once had vogue, merely on account, perhaps, of the name it bears, and the reminiscences attached to it, is a totally different matter from reverting to it for the purpose of studying and appropriating to ourselves its better qualities. To adopt by-gone tastes and fashions by taking them just as we find them, is like transplanting dead trees. Our own ideas being exhausted, we are fain, for the sake of a little temporary novelty, to resort to such as had been worn out previously, and into which we are incapable of infusing the vitality and spontaneousness requisite for reviving more than merely nominally any past style.

Had we any fundamental and rational principles of taste, the sudden changes of fashion, now so frequent, from one extreme of taste to another, could not occur. Change there still would be, but it would be gradual, natural, progressive—the result of improvement, and regulated by motive. At present, those who are artists do not attempt to guide or regulate the taste of the public in those matters which, however influential upon a correct feeling for art generally, are not immediately connected with their own pursuits and practice. Architects themselves do not bestow any study upon furniture and fittings-up, or on other internal decoration than what actually belongs to construction. They do not qualify themselves even for superintending such matters, but turn them over entirely to those who, however clever they may be in their way, are rather artisans than artists—very capable of executing, but seldom capable of designing more than piecemeal ornament and detail. No wonder, therefore, that we so seldom find completeness of *ensemble* and due artistic keeping in even the most sumptuously furnished apartments. Every separate article or ornament may be irreproachable in itself, yet the reproach of unequal and careless, if not actually bad taste, may be deserved by the discordant assemblage of them. An upholsterer's show-room, or a furniture bazaar, or a curiosity shop is one thing, and a tastefully furnished room quite another. Fashion, however, can sanction the most palpable absurdities and extravagances; and at Paris, it was for a while, in the time of the Consulate, the fashion to assemble in the same room a congress of chairs and other pieces of furniture, all differing from each other; a whim so outrageous, as to be excusable only as a satirical symbolisation of political chaos and conflict.

In his highly interesting comparative view of the *material* state of society in England, and its progress since 1685, Mr. Macaulay has omitted to touch upon the subject to which we are rather calling attention than pretending to treat of it formally. Yet it is what was surely not wholly undeserving of a few touches of his graphic pen, more especially as there is now a hankering after what smacks of the *perruque*, or even of Queen Bess's ruff or farthingale in *ameublement*,—which is, in our opinion, of evil augury to sound taste. In a *bonâ fide* old English mansion, contemporary furniture that has been a heir-loom for successive generations, is in its place, and in keeping with all the rest. It possesses there an historic value which reconciles us to its want of elegance. Its cumbrous stateliness, and even its clumsiness, is quaint, and carries with it an air of the formal aristocratic dignity affected in by-gone times. There it is genuine costume, and impresses us like the graphic descriptions of similar interiors and their accessories in Scott's novels. In Dutch pictures again, and in Hogarth's plates, the furniture and fashion respectively exhibited in them are the characteristic stage-properties of the scene; but to imitate things of that kind now-a-days, amounts to a confession that we have learnt nothing whatever from all that we have become acquainted with, have studied, or pretended to study, in the interim; but are just as far off as ever from having any settled and rational standard of taste. Nay, after having cheated ourselves into the belief that we were beginning to appreciate and arrive at a degree of refined elegance previously unknown to modern times, we are fain to relapse, by way of change, into the fulsome tawdriness and gewgaw fancies of the Louis-Quatorze and Louis-Quinze periods, which, if they can lay claim to the name of style at all, may be classed with that of the pastrycook and confectioner. Such mode of decoration takes cognisance of adscititious ornament alone, and makes that consist of nothing more than mere scallopings, crimpings, and zig-zags; so that in spite of its seeming variety, it is essentially monotonous, and even its very freaks betray barrenness of invention. It is capable of but one expression, that of arrogant, purse-proud pomposity.

Instead of turning to such radically vicious and tasteless manner, we should do better to go back to the days of Adam at once—of Robert Adam we mean—who, prosaic and feeble as was his taste in architecture, did something to improve the general style of furniture. Praiseworthy it certainly was in him to endeavour to place that subordinate branch of design upon a much more artistic footing than he found it. It is one, however, that requires talent of a peculiar kind; nor is it every architect who could descend to it without falling also, even if he would *condescend* to make the attempt. Heideloff, for instance, has done much for the illustration of German mediæval architecture, yet has failed most signally in his designs for Gothic furniture, most of which violate every principle of convenience as well as of beauty. The taste which he has shown is so truly detestable as to be harmless, since it can hardly fail to disgust at first sight; and yet we ought to have our doubts as to that, when we find such portentous monstrosities paraded as "admirable designs in furniture," in an English publication which professes to watch diligently over the interests of every department of art.

REMARKS ON THE SANITARY LABOURS
CONNECTED WITH THE
DRAINAGE OF THE METROPOLIS.

"When we inquire what facts are to be made the materials of Science, perhaps the answer which we should most commonly receive would be, 'TRUE FACTS,' as distinguished from any mere inferences or opinions of our own."—WHEWELL: 'Philosophy of the Inductive Sciences.' Vol II., B. 11, p. 193.

Thirty years have now elapsed since the inquiry, instituted in 1819, respecting the supply of water to the metropolis, led Mr. John Martin the artist, to the consideration of our water supply—the relieving the River Thames from its impurities—and the preserving the sewage for agricultural purposes[1]—the three most important points connected with the present metropolitan drainage question.

While it is to be deeply deplored that more successful means have not been found or adopted for the more speedy alleviation of the evils afflicting the public health of the metropolis generally, but more particularly of that portion of the labouring population which, for want of time and means, are unable to avail themselves of such private remedial measures as are within the reach of the comparatively richer part of the community, we cannot conceal

[1] See Second Report of Select Committee on Metropolis Improvements. Quest. 1887, p. 148. 1838.

from ourselves, after a due examination of the merits of the labours which have put us in possession of the conflicting opinions, and, in the majority of cases, valuable evidence embodied in the Reports of the several Commissions, instituted at different times with a view to ameliorating our sanitary condition, that though the progress of improvement has been slow, it has been *sure*—though not marked by many of the results we had a right to anticipate. That so great a delay has occurred, is not, therefore, to be attributed to the want of talent and exertion on the part of the public bodies appointed to examine the special means requisite; or of ability—so far as the resources of the present existing state of certain branches of science admit of—of our professional men, a large portion of whose contributions embody, perhaps, the most valuable additions that have been made of late years to engineering science generally; but in some measure to the want of such *data* as cannot be obtained from the testimony of former experience or former practice, and concerning which the Commissioners have only been able to elicit conflicting opinions, the more difficult to decide upon, there being at least a somewhat general agreement among the witnesses, as to the inappliancy of received formulæ as guides for the framing of future plans—thus setting aside not only the practice, but also the received theory of former years.

The summary of the questions to be settled before any proposed system can be generally deemed advisable, includes, on account of this disagreement of opinions, a great number of heads, respecting which further investigation becomes consequently necessary; and in order to obtain indisputable conclusions on the majority of these points, such investigations ought to be founded on trials, when possible, of the respective merits of the different proposals made for effecting the same objects, where so proposed, or deduced from correct experiments when the same practical means are advocated; but a diversity of opinions exist respecting the theoretical means of application of such practice, whether in the shape of formulæ or otherwise, to varying circumstances, simply dependent on mere local circumstances.

For instance—Mr. W. Hosking[2], Professor of Architecture in King's College, and Mr. John Phillips[3], C.E., Surveyor of Sewers, advocate the oviform sewer with the small end downwards; on the other hand, Mr. Joseph Gwilt[4], Architect, Surveyor of the Lambeth District of Sewers, and author of various works, one on the strength of arches, which "has passed through three editions;" and another, a complete encyclopædia of architecture—of construction in all its branches, prefers turning the oviform drain of the abovenamed gentlemen upside down; and argues the advantages of the big end over the little end for the lower side of the section, but favours more particularly the vertical-sided form with semicircular top and bottom; while the late Mr. Butler Williams[5], C.E., and Mr. Henry Austin[6], Secretary of the Board of Health, express their opinions in favour of circular drains. Each of these advocacies is duly backed by mathematical reasons of some kind or other (we say of some kind or other, since they cannot possibly all be correct); and as the matter to which they relate belongs to the *mixed* instead of the *pure* mathematics, it becomes extremely difficult, nay, impossible, without actual proofs of demonstration, to give such a judgment on any such point as would be deemed satisfactory by all.

In the mere examination of a witness, there are difficulties to contend with. The following is asked:—

"Have you had any experience, or would you state it as a result of which you have no doubt, that an egg-shaped sewer, with the broad end downwards, will, with the same run of water, discharge more quickly, and keep itself clean better than an egg-shaped sewer with the narrow end downwards?—I should say it would clear itself better because there would be less friction upon a circle than there would be on the parts of an ellipse[7]."

Here we have a question, which at first sight seems clear, important, and well put; but which is, in point of fact, essentially faulty, inasmuch as the answer is a variable one, dependent on the very condition left out, viz., the *height* of flow in the oviform section, "the same run of water" not being a sufficient condition, admitting as it does of the very opposite answers, according to the circumstances of "quantity" left out. We proceed with the evidence:—

"Do you not think, that is a fact which may be determined by actual experiment?—No doubt it may."

"And ought not it to be?—I can see no objection to it whatever."

A dangerous question cautiously answered. A simple unguarded affirmative answer would have been an admission of *doubt* on the part of the witness; but here the answer implies, "If you wish it for your own satisfaction, well and good: as to myself, I am perfectly satisfied as to what the result would be." Consequently we obtain a decided unconditional answer to a question, which, not being sufficiently explicit, only admits of a variable one.

We have brought forward an instance, out of many others, to show how difficult it is to deal satisfactorily with matters of this kind; and how essential it is to do our utmost to divest ourselves of all prejudices we may possess for or against any opinion at all likely to influence our decision. Unfortunately, ours are many and deeply-rooted. Our pure mathematics are indisputable—their proofs incontrovertible; but their practical application to the arts of life and civilisation, requiring *data* derived from observation and experiment, engenders difficulties which render the investigation of the applied sciences often perplexing—too often intractable. Hence the origin of what are termed "false theories"—of the diffidence generally shown towards opinions purporting to be new—hence the great distinction made between theory and practice—itself a false notion. The *mixed* sciences, as the term implies, require, less or more, certain admixtures of the "pure" and the less certain—of the theoretical and the practical; any bias of the mind, therefore, in favour or against either of these, theory or practice, as regards "applied" cases, does not only come under the head of prejudice, but is, besides, a false impression; since, correctly speaking, neither can be used independently of the other in any such application. We can no more progress in the theoretical investigation of any branch of mixed science, without experiment and observation, viz. practice—requiring, as we do, "new" facts to build upon—than we can hope to obtain "general" conclusions from mere practice, without inductive reasoning; since "experience cannot conduct us to universal and necessary truths: not to universal, because she has not tried all cases—not to necessary, because necessity is not a matter to which experience can testify." And, therefore, we must insist as strongly against the practice not founded on theory correctly induced from facts, as we do against theory not founded on facts correctly deduced from experience.

When we consider the many difficulties attending the investigation of "truth"—when we reflect on the slow progress of some of the inductive sciences—on the too frequent want of necessary data—and that hydraulics is, perhaps, of all the physical sciences, that respecting which the least satisfactory results have been obtained, after having occupied the attention of some of the leading minds science can boast of—when we bear in mind the difficulty of introducing new views, however plausible—of the prejudices existing in favour of received practices, however faulty, we cannot wonder that the question of the means of an efficient drainage of the metropolis is still an undecided one; although, from a careful examination of the labours of the Sanitary Commissioners (as we have already said), we cannot but allow that they have done much that was necessary towards the end in view—much for which the next generation of engineers will thank them.

In consequence, partly, of the difficulties we have thus briefly alluded to, thirty years have elapsed, as we said before, since Mr. Martin's attention was first directed to the three most important questions connected with the drainage of London, without any decision having been come to respecting either of them, though the labours instituted by the legislature have, of late years, been incessant. His opinions, however, were not published until 1828, when his "first suggestion for not only relieving the river from its impurities, but preserving the sewage for agricultural purposes," appeared. In 1830, Mr. Ainger, the then conductor of the *Gardeners' Magazine*, published in that work his plan for "preserving the purity of the Thames, by constructing covered drains along the sides of the river to receive the minor drainage." Shortly afterwards, the proposals for improving the banks of the river were submitted to the Committee for Improving the Navigation of the River Thames, whose Report was presented to the Court of Common Council, 3rd August, 1832, and contains some useful information on the questions of embanking, and the formation of quays. In July, 1834, Mr. Martin presented to the Select Committee of the House of Commons, appointed to inquire into the law respecting Metropolitan Sewers, his plan, published in 1828, the objects of which were described to be—"1st, to materially improve the drainage of the metropolis; 2nd, to prevent the sewage being thrown into the river, and to preserve in its pure state the water which the inhabitants are necessitated to use; 3dly, to prevent the pollution of the atmosphere by the exhalations from the river, and the open mouths of the drains; and, 4th, to save

[2] First Report of the Health of Towns Commissioners. Quest. 369, p. 39.
[3] First Report of the Metropolitan Sanitary Commissioners. Evidence, No. 13.
[4] First Report of the Metropolitan Sanitary Commissioners. Evidence, No. 20.
[5] First Report of the Health of Towns Commissioners. Quest. 5828, p. 380.
[6] First Report of the Metropolitan Sanitary Commissioners. Evidence, No. 23.
[7] First Report of the Metropolitan Sanitary Commissioners. Evidence, No. 20, p. 101.

and apply to a useful purpose the valuable manure which is at present wasted by being conveyed into the river." On the 18th of June, 1838, he was examined before the Select Committee appointed to consider plans for the Improvement of the Metropolis; and on the 11th of July following, his matured scheme of his parallel sewers—the first idea of which, he tells us,[8] was originally published in 1829—was communicated by him, in a Report to the Committee. About this time, Mr. Thomas Cubitt devised his plan. Meanwhile the Poor Law Commissioners had been at work. On the 14th of May of the same year appeared the Reports[9] of Drs. Arnott and Phillip Kay, "On the prevalence of certain physical causes of fever in the metropolis, which might be removed by proper sanitary measures;" and of Dr. Southwood Smith, "On some of the physical causes of sickness and mortality to which the poor are peculiarly exposed, and which are capable of removal by sanitary regulations, exemplified in the present condition of the Bethnal-green and Whitechapel districts, as ascertained on a personal inspection," which led to the inquiry, instituted in 1839, respecting the sanitary condition of our labouring population, and the production, in 1842, of the local reports, and the general one, by Mr. Edwin Chadwick, from the Poor Law Board to Sir James Graham. We pass over the continued inquiries respecting the state of the Thames. In 1844, the Commission for inquiring into the state of Large Towns and Populous Districts, was instituted. Their first Report appeared in June that year, and the second in February, 1845; then followed the consideration of the plans for the application of the sewage of the metropolis to agricultural purposes, and of the schemes proposed by Messrs. Wicksteed and Higgs—by the Select Committee of 1846—the further inquiry into the special means requisite for the improvement of the health of the metropolis—the rapid succession of the Reports of this Board in 1847-8, and the passing of the "Public Health Act, 1848," August 31st—the consequent appointment of the General Board of Health—of a first Metropolitan Commission of Sewers, and of their Ordnance Survey Committee—of a second Metropolitan (and a City) Commission of Sewers—their consideration of proposed schemes—their appointment, on the 15th of December last, of a sub-committee to report thereon—and finally, the communication of the Report, at their special general court, March 15th, 1850. Such is only a brief and imperfect retrospect of the chief events connected with the desired improvement of the health of the metropolis during the 30 years' peace. The result of all this labour is not of the satisfactory kind we should wish to have to record. We are told by the sub-committee, consisting of Sir John Burgoyne, Capt. Vetch, and Messrs. Harness, Rendel, and Stephenson, that "they have carefully examined and considered the whole of the plans and suggestions submitted to the Commissioners for the drainage of the metropolis;" that "though they do not deem themselves justified in recommending any one of these schemes for adoption, as a whole, they yet think that one," out of 116 plans for drainage, and 21 miscellaneous suggestions, "contains many of the main elements of a sound and practical system of drainage;" but that a portion of this scheme "involves great difficulties," and that they "consider it decidedly bad and objectionable." The remaining 115 are all deemed less or more faulty or unavailable.

This conclusion we fully expected. We observed at the beginning of this paper that the delay which has taken place is not to be attributed to want of talent or exertion on the part of the persons concerned in the inquiries, but to the want of necessary *data* on which to build a well-founded proposal. Of the data required for this purpose there are two distinct kinds, viz.:—Data derived from local circumstances, indispensable in framing a plan; and data connected with details of construction necessary for carrying into effect a proposed scheme: our want of the latter kind of data we have already endeavoured to illustrate; with regard to the first kind the Committee express themselves to the following effect:—"It is probable, that were we now called upon to deal with the drainage of London, as an original question, and wholly without reference to previous proceedings, we might reflect that a well-conceived and maturely-digested plan of general drainage could not be framed without a larger stock of local information of an accurate and specific character than could be collected by the unaided efforts of individuals, or made accessible to them without undue expense and inconvenience. The effect of this deficiency of the necessary information has become apparent in several of the schemes submitted to us, which, though well conceived, so far as regards their general features, are wholly inconsistent with the levels and other natural conditions of the localities to which they are intended to apply;" and Mr. Sheriff Lawrence, in his address to the Board, after the reading of the Report, adds, "Many whose plans were exceedingly good, had commenced them and prepared them without having sufficient *data* to go upon, and had been unable to fulfil their intentions in the manner which he was quite sure they would have done if they had had proper *data* to go upon. That, however, was no fault of the Commissioners, because *they were not themselves furnished with the materials to furnish such data;* but at any rate, there had been no favouritism in the decision given." Doubtless, as the decision shows. The want of the first kind of data is now admitted—*later*, we shall have to acknowledge the want of the second kind.

Accordingly, we find that few engineers of repute—those who have devoted their special attention to this one subject for the last few years, of course, excepted—have sent in plans. We look in vain in the list of competitors for the names of our principal R.E.'s or M. Inst. C.E.'s; and we cannot be astonished at the conclusion arrived at respecting the merits of the majority of the schemes. How so many persons can have thought proper to venture to send in plans under the circumstances described, is to us a mystery. Many, we fear, embraced the popular opinion that the drainage of London was wholly a question of outlet, and that that once found, the necessary details of a comprehensive scheme must naturally follow. The late outcry for an outfall, was, and is still, for the present, a mere fallacy; which simply reminds us of Archimedes asking for a prop, as the only condition necessary to enable him to lift the world—with this difference, however, that, like the Egyptian astronomer who, while calculating the motions of the planets, fell into a bog in his own garden, we can analyse accurately the impossible case proposed by Archimedes, but are perfectly helpless as regards the other, which nevertheless necessitates an immediate decision. We have the sewage of a vast population to get rid of some how: one person offers to treat it chymically; another proposes to empty it into the Thames; a third is of opinion it should be carried off under the bed of the river; and a fourth maintains that, on the contrary, it ought to be raised by steam. What with one person wishing to collect it in tanks, and another to drown it, a third to sink it, and a fourth to raise it—what with dry manure, and highly-diluted ditto, sinking shafts and erecting engines—we have now such conflicting opinions on all points, that we are even beginning to question the truth of the very premises we started with; and the only conclusions respecting which there can be said to be a general agreement of opinion, are—

1. That the present provisions for the drainage of London are insufficient, and in themselves defective.

2. That the thorough drainage of the metropolis is desirable, if it can possibly be attained.

3. That the pollution of the Thames with sewage is to be avoided, provided there be a possibility of effecting the necessary drainage without it, as outfall, within the limits advisable for all sanitary requirements.

4. That refuse-sewage has intrinsic value, which ought to be made available.

5. That a diversity of opinions exists respecting the details connected with town drainage.

6. That this diversity of opinions has prevented, hitherto, effective means being devised to remedy the evils to which a large body of this population is still subject.

7. That something ought to be done.

Let us now consider the question itself, and take a common-sense view of the case.

The premises we start with are the four first of the above conclusions. We send for an engineer. We request him to undertake to remedy the evils we complain of. What is his first step? His first step is to ask for "instructions" respecting all such points as are not within *his* control, and which must in any way influence his decision: "Your water supply is defective? What are the intentions of the legislature as regards its improvement? Will the supply be limited or constant? If the first, to what extent? Can you provide me with a supply in certain districts, if required, and to what extent? Will the same provision be made throughout the metropolis; and if not, what will the respective provisions be for each district? &c. &c.—You wish to preserve the sewage for agricultural purposes? Will it be sufficient to have it conveyed to one point, say the Essex marshes; or do you require means of direct communication into the country by rail, in different directions? If so, to what extent and in what directions? In what state must the refuse be delivered? To what extent diluted? Will the whole of it be required, or only a part, during one portion of the year; and if the latter, to what probable extent? &c. &c.—

8 Second Report of the Metropolis Improvements (1838). p. 149.
9 Fourth Annual Report of the Poor Law Commissioners. App. A. No. 1.

Are you prepared to answer these questions?—if not, and you request me to come to my own conclusions respecting these preliminary points, I must put off the main one of an effective drainage, until I have instituted the necesary inquiries in connection with some of them; and obtained the further information, over which I have no control, respecting the remainder."—His next step is to obtain the required local data, which would be comprised principally in—1st, an accurate trigonometrical survey of the whole area at all likely to be necessary for a full investigation; plotted, first, to a sufficiently large working scale for all matters of detail, say five feet to the mile; and, secondly, to a smaller scale of perhaps eight inches to the mile. 2ndly, a net-work of levels plotted on both plans, in contours at vertical equi-distances, say of two feet; with, on the larger plotting, a second, and may be a third, set of secondary contours, equi-multiples of the first, on all such portions necessitating the same, on account of the lowness of districts or other cause. 3rdly, a skeleton plan of the present drainage works, the levels of the underground portions of which would be embodied chiefly in, 4thly, a set of longitudinal sections, reduced to the same datum as the contours, of all the present main and branch sewers and drains. And, 5thly, other local information of different kinds, respecting the nature of which it is not necessary for us here to dwell. Are we prepared to furnish these? —If not, we must give up all thoughts of a "comprehensive" scheme, *truly capable of being found efficient in practice*, until we have obtained them.

Admitting these requirements obtained, an engineer would still have a great number of difficulties to contend with, for the reasons stated at the beginning of this paper; and the result of his labour would probably be the production of two or three schemes, varying in principles—each with advantages and disadvantages, of which it would be his duty to point out the nature. For instance, one plan might embody a comprehensive scheme, depending upon natural resources as far as possibly available, with many of the consequent advantages of a natural system of drainage, but defective in as much that these natural resources are not available in certain low districts without flushing—itself an artificial means—and that a portion of the drainage would be intermittent. The next, on the contrary, might provide for the removal of the sewage by artificial power; it would have the advantages over the first scheme, of being constant and thoroughly effective throughout—its defects would lie in the adoption of purely mechanical means and extensive machinery, instead of merely the natural power afforded by gravitation. The third would probably be a combination of the principles of the two first, according to local circumstances of level, including only the minimum amount of artificial power consistent with a constant and truly efficient discharge of the refuse. This last would probably be recommended.

Had these steps been followed more strictly, we should now be in a better position to report progress; but as it is, we are anything but prepared to frame a comprehensive plan. Moreover, we fear our progress, of late, has been like that of the crab—backward: we are beginning to doubt that the pollution of the Thames is an evil; and soon we shall be informed that the defective state of our drainage is in a great measure a fallacy, and that, with a few improvements—a main sewer here, and a brick drain there—we shall do very well indeed. This, however, is not the greatest evil we have to dread; we have to fear the endeavour, by the waste of hundreds of thousands, to force the river Thames to do—by what we are pleased to term "natural means"—what, in spite of Mr. Sheriff Lawrence's opinion, she never was intended to do. The extraordinary accumulation of population on the river bank of Middlesex is a purely accidental circumstance, perfectly independent of nature, her laws, or her provisions; and the business of engineering is to *adapt* the resources she has so bountifully placed at our command for our well-being and happiness, and not to force upon her what she never provided for, when fortuitous circumstances of man's own creating render her provisions inadequate to his demands.

East Indian Railways.—Amongst the passengers for India by the steamer of the 20th ult., was Mr. George Turnbull, the resident engineer of the East Indian Railway Company, and his staff. A vigorous prosecution of the works is now looked for. From the recent reports of the Company, it appears that more than 300,000*l.* of the capital is already paid-up, upon which the guaranteed interest of 5 per cent. is accruing, and that arrangements have been made with the India House, by which, at the expiration of the current year, the paid up capital will amount to about 500,000*l.*, or one-half of the million required for the first section of the line.

INSTITUTION OF CIVIL ENGINEERS.

Feb. 26.—William Cubitt, Esq., President, in the Chair.

The paper read was "*On the Street Paving of the Metropolis, with an Account of a peculiar system adopted at the London and North-Western Railway Station, Euston-square.*" By Mr. William Taylor.

The paper commenced by directing attention to the importance of a good system of paving, in conjunction with a more perfect plan of sewage for all large towns. The paving of the metropolis has too long been carried on under an antiquated and unscientific system, of using large masses of granite, placed upon an inefficient substratum; the consequences of this were great noise, an imperfect foot-hold for the horses, danger of the constant fracture of the springs and axles from the jolting over an uneven surface, and great expence of repairs. The macadamised streets were manifest improvements on such a system, but the surface was not found capable of resisting the heavy traffic of the main thoroughfares of the City. The defects of the wood pavement so greatly exceeded the merits that it had been nearly abandoned.

Impressed with the disadvantages of the present system of paving, Mr. Taylor tried an experiment about ten years ago, by covering a surface subject to very heavy traffic, and subsequently, about five years since, entirely paving the departure side of the Euston Station of the London and North-Western Railway in a peculiar manner. The system was upon entirely new principles. The method employed was, after removing the subsoil to the depth of sixteen inches, to lay a thickness of four inches of strong gravel, equally and well rammed, then another layer of gravel mixed with a small quantity of chalk, or hoggin, for the purpose of giving elasticity, the ramming being continued as before; a third coat of the same materials, was then laid and rammed, a regular degree of convexity of surface being preserved. The stones used were of Mount Sorrel granite, dressed and squared into regular masses of four inches deep, three inches thick, and four inches long: these stones were laid in a bed of fine sand, one inch in thickness, equally spread over the surface of the substratum, and they were carefully placed, so that no stone should rock in its bed. The whole surface was then well driven down with wooden rammers, weighing fifty-five pounds each. The small size of the stones enabled them to be well rammed home, so that the surface of the pavement never sunk, and the hardness and toughness of the material, prevented the stones from being worn down by any traffic, however heavy.

It was stated, that this system was found infinitely preferable to the employment of large stones, and the statement of cost was vastly in its favour; the price of the ordinary kind of granite paving, in London, being eighteen shillings per superficial yard, and the maximum cost of the new or "Euston" pavement, including the substratum, was not twelve shillings per yard, and deducting the value of the old stones, not (in this latter case,) claimed by the contractor, the nett cost would only be nine shillings per yard.

The system was stated to have been very extensively employed at Birmingham, and many provincial towns, and it appeared admitted, that the beauty of the pavement when completed, was only equalled by its extreme durability, and by the manifest advantages it offered in its noiselessness, good foot-hold for horses, freedom from jolting, and the small repairs it required.

It was suggested, that the different Paving Boards should make a trial in streets of small traffic, by lifting the large stones, and cutting them into small cubes, or rectangular pieces, of three inches in depth, for the future pavement; so that a good field would be afforded for the practice of the paviours, which would enable them to be better qualified for the task of extending the system to the more important thoroughfares: by this means, too, a large surplus of stone would be accumulated for paving, and the refuse would be valuable for macadamising the roads in the outskirts.

March 5.—In discussing the merits of Mr. Taylor's system, it was contended that a rigid and unyielding substratum had been tried by Mr. Telford many years since, and had been used with success in some parts of the City paving, up to the present time. The average duration of the pavement on the streets in the City was stated to be eighty years, but that it was constantly subject to injury, from being moved by the water and gas companies. The pavement on London Bridge by Sir John Rennie was instanced as a good, but expensive, example of the use of long narrow stones; and that by Mr. Walker, on Blackfriars Bridge, was quoted as another instance of the success that might be obtained by great care in the preparation of the substratum, which was of concrete, and the stones of the pavement being laid with more than ordinary skill and care. The results in both cases were eminently successful, but it was allowed that such an expensive system, however beautiful, was not applicable to the ordinary streets.

It was admitted, that, although the principal streets of the City and the main thoroughfares of the West and East ends were well attended to, yet it must be allowed, that the paving of the majority of the streets was not in a satisfactory state, and it was attributed, in a great degree, to the want of a definite system being adopted; there being too many authorities in the shape of parish paving boards, each of which had a separate surveyor, too often equally inefficient and ill-paid. The water and gas companies appeared to vie with each other in their endeavours to destroy the paving; and a portion of the Strand was quoted as having been removed thirty times within two years.

With respect to Mr. Taylor's system of paving, it was contended, that the Mount Sorrel granite was a very superior material, both as regarded its toughness and durability, and that its natural structure enabled it to be worked very advantageously into the small cubes. The main feature of the system was the selection of the material for the substratum, and the careful preparation, so as to afford a sufficiently rigid, but yet imperceptibly elastic bed, whereon the small cube stones should rest. These stones being well driven down by repeated blows of light rammers, attained a degree of solidity which defied the heaviest traffic; and in the towns where the system was employed, considerable economy had resulted. The surface of the paving approached as nearly as possible to that of a macadamised road, affording even a safer foothold to the horses, and with less noise of passing vehicles. The surface possessed extraordinary durability, and it might be considered as a solid mass of granite. It was announced that within a few weeks there would be specimens of Mr. Taylor's system of paving laid down at the entrances of Hyde Park, where they would be subjected to regular traffic of a destructive nature, and which would be under constant observation.

A model of an improved Crossing Point was exhibited by Mr. Duncan, of Leeds; the notch in the rail was shown to be done away with, and the two rails in it were so dovetailed together, as to render any vertical motion between them impossible, thus materially strengthening the crossing.

A piece of brickwork, set in Greave's blue lias lime, and which had been kept under water for nine days, was also exhibited. This material was composed of one-third of lime to two-thirds of burnt clay; and it was stated to have been used with great success in the tunnels on the Great Northern Railway, as well as in many hydraulic works, in which it was as durable as cement.

March 12.—The paper read was, "*On Tubular Girder Bridges.*" By Mr. W. Fairbairn, M. Inst. C.E.

The author commenced by stating, that the chief points to be taken into consideration were:—First, the application of a given formula, for computing their strength; second, the excess of strength that should be given, over the greatest load that could be brought upon the bridge; and, third, the effects of impact, with the best mode of testing the strength, and proving the security of the bridge.

In the first place, it had been determined by experiments, that, in order to balance the two resisting forces of tension and compression, in a wrought-iron tubular girder, having a cellular top, the sectional area of the bottom should be to the sectional area of the top, as eleven to twelve; and that until this proportion existed, the usual formula could not be applied; this formula was, that the breaking weight was equal to the total area, multiplied into the depth, and into a constant (80), and divided by the length of the girder $\left(w=\frac{adc}{l}\right)$.

Considering the particular case of the Torksey bridge, the mean sectional areas of the top and the bottom, being respectively 51·08 square inches and 54·93 square inches, the latter was in excess of strength over the former, so that a reduction of the area of the bottom from 54·93 to 46·76 square inches might have been made with propriety, and would have been in conformity with the formula. By calculation, the ultimate strength of the bridge was found to be 1,152 tons, whilst the greatest total load, including the weight of the girders, &c., was only 372 tons; this gave a strength, greater than the heaviest rolling load that could be brought on the bridge, in the proportion of nearly five to one. Although, therefore, the proportion of the girders was not exactly that which the author recommended, he considered that "they were, nevertheless, sufficient to render the bridge perfectly secure." This conclusion was arrived at without taking into consideration, the amount of additional strength derived from the continuity of the girders, across the central pier. The exact proportions recommended were given in two tables extending respectively to spans of 150 feet, and of 300 feet. The depths of the girders of the first class were taken at one-thirteenth of the span, and those of the second class at one-fifteenth of the span. The author then investigated the effects of impact at different velocities. It did not appear that experiment established the fact of increased deflection at high velocities for in several experiments on a large scale, he had found the deflection as nearly as possible the same at all velocities. He concluded by recommending that the tests to be applied should never exceed the greatest load the bridge, was intended to bear.

Remarks.—In the opening of the discussion by Mr. Fowler, Mr. Bidder and Mr. Eaton Hodgkinson, it was remarked, that satisfactory as it was to have the confirmation of Mr. Fairbairn's authority, for the perfect safety of the bridge for all purposes of traffic, it would have been desirable, that he should have extended his calculations a little further, into the question of the increased strength derived from the continuity of the girder, across the central pier, which augmented the total strength fully one-fourth. It was also argued, that the excessive proportion of the bottom of the girder, although not an economical disposition of material, was in itself an important addition to the strength of the girder.

The definite proportions assigned in the paper for girders were disputed, and the attempt to assign empirical rules for the practice of engineers, in structures of this novel character, was earnestly deprecated.

It was important also to remember, that the large proportion of the bottom of the beam brought into action a corresponding quantity of the upper part of the side plates, in aid of the top. Thus it appeared, that if the subject had been pursued further, the proportion of five to one, by which the proportional strength of the beam, over the rolling load, was represented, would have been, from various causes, materially increased.

March 19.—The subject of Mr. Fairbairn's paper was resumed. Messrs. Wild, Pole, Rennie, Scott Russell, Eaton Hodgkinson, Walker, Glynn, Bidder, Professor Willis, General Pasley, and Captain Simmons, R.E., examined the question at great length, and under all views, illustrating their position by diagrams and models, used in the experiments and in the mathematical investigation.

It was stated, that after the remarks made at the last meeting, it was merely requisite to describe the experiments alluded to, and before doing so, to briefly describe their object.

In the Report of the Government Inspector, the limiting strain required for the public safety was defined, and the Torksey bridge had been condemned for not complying with those conditions. A calculation, therefore, had been made to ascertain the actual strain on the bridge. It appeared, however, that it was really *less* than the limit prescribed by the Government Inspector. The experiments instituted were for the purpose of testing these contrary results. It was also stated, that in the paper there were many objectionable points, but particularly one that was positively dangerous.

The author had not only omitted the effect of the continuity of the Torksey girders, but stated, that it was *safer* to do so. Now all writers upon the subject, and all who had considered the matter, agree that in a continuous beam the effect of continuity was most important, and that in a *perfectly* continuous beam, the strain over the supports was even greater than elsewhere. It was therefore submitted that this was not the part, the consideration of which it could be "safer to omit."

The form taken by a continuous beam, when uniformly loaded, was convex over the supports, and concave between the points at which the convexity ended; at these points of contrary flexure, the horizontal strains were null, and the beam might then be severed, without altering its condition. The virtual length of the beam, in the Torksey bridge, was determined by the distance between the exterior support and the point of contrary flexure; and it was to determine this point practically that the experiments were instituted. It was shown that this point was $21\frac{3}{4}$ feet from the centre support, and that hence the length of the beam was reduced from 130 feet to $108\frac{1}{4}$ feet.

The compressive strain upon a girder of this length, loaded as prescribed, was $4\frac{3}{4}$ tons per inch, being less than the limit defined. Consequently, it was asserted, that the Railway Company to whom this bridge belonged, had been deprived of its use, not in consequence of any omission on the part of their engineer, but in consequence of the inability of the Government authorities to appreciate the strength that had been provided.

In reference to the application of formulæ to the calculation of the strength of the girders, it was considered desirable, in such an important case, not merely to form a general approximate notion of the strength of the bridge, but to ascertain, with all possible exactness, the nature and amount of the strains to which the structure was exposed; and this could only be done, by using a comprehensive process of calculation, which should embrace all the elements affecting the strength of the bridge.

The effect of the continuity of the girders over the two openings, was carefully considered, and the nature of its effect upon the strain was explained, as deduced from the application of the most modern mathematical investigations, and it was demonstrated that the strength of the beam was thereby augmented above one third.

It was then shown, how the rules for estimating the strength of elastic beams, were rendered applicable to the case of the Torksey bridge, and the results proved, that when the bridge was weighted with the load prescribed by the Government authorities as a test for its strength, the strains of compression and extension were only one half of what competent authorities had stated might be safely applied.

The diagrams exhibited, shewed the results of mathematical calculation, as applied to the Torksey bridge girders, and the remarkable coincidence of these, with experimental results obtained by other investigators in an entirely different manner, was insisted on, as a proof of the correctness of the conclusions arrived at.

It was stated, in reply to a remark upon the increased deflection due to velocity, that the result of the experiments tried by the "Cast-Iron Bridge Commission," proved, that "this increase was wholly insignificant in beams of the length and stiffness of those of the Torksey bridge."

The discussion was summed up by its being stated, that, with one exception, all those who had spoken during both evenings, agree that the formula given in the paper was empirical and not trustworthy; that the effects of percussion and increased velocity were practically only shadowy visions; and as it was admitted, that in the calculations of the Government Inspector, the effect of continuity was neglected, and as it had been proved that the strain was less on the bridge than that assigned as requisite for the public safety, and that it was, in fact, amply strong, it was evident, that the public had been wrongfully deprived of the use of the bridge, and the Company had been prohibited from gaining the just return for the capital invested, in consequence of an incomplete investigation, and the assumption of untenable formulæ.

ON ARTIFICIAL BREAKWATERS.

On Artificial Breakwaters, and the Principles which govern their Construction. By Mr. A. G. FINDLAY.—(Paper read at the Society of Arts, London.)

Mr. FINDLAY's paper commenced by stating, that it was not wished to pronounce upon the feasibility or impracticability of any of the numerous plans which have, from time to time, been proposed for the construction of breakwaters, but to submit some facts, drawn from natural effects, showing the forces to which such structures must be subjected.

The paper, therefore, was naturally divided into two parts. The first, which related to the action of the waves, and its collateral subjects; and the second, which was postponed for a future evening, will relate to the various forms which have been given to sea-barriers, and the history of the progress of those now in existence.

The principal difficulty in establishing a fixed breakwater was shown to be the enormous force of the waves. The form and nature of sea-waves generally were alluded to, and Mr. Scott Russell's system described. Of the dynamic force exerted by sea-waves, it was stated that their greatest force was at the crest of the wave before it breaks; and its power in raising itself was measured by a number of facts. At Warberg, in Norway, it rose 400 feet, January 21, 1820: on the coast of Cornwall it rose 300 feet in 1843. Other examples, as the singular "Souffleur" at the Mauritius, &c., were cited, showing that the waves have raised a column of water equivalent to a pressure of three to five tons per square foot; a result in accordance with Mr. T. Stevenson's observations with the Marine Dynamometer, which was described.

It was shown by a table that the velocity of waves was dependent on their length; that waves of 300 to 400 feet in length from crest to crest, travelled with a velocity of 20 to 27½ miles an hour, and this whether they were 5 or 54 feet in total height; this velocity alone, should they become primary waves of translation, would give them a great percussive force. That waves travel very great distances was instanced by several facts. That they are raised by distant hurricanes and gales was noticed, by their being felt simultaneously at St. Helena and Ascension, though 600 miles apart; and opinions quoted, that these rollers, or ground-swell, at times originated near Cape Horn, 3,000 miles distant; rendering it more than probable that tropical hurricanes will send storm-waves to our own shores.

That it was not only at their surface that waves exerted great power, but that they reach in their action to the depth of eight fathoms and upwards, was shown by the operations for the recovery of the treasure of H.M.S. *Thetis*, which was wrecked and sunk at Cape Frio, Brazil, in 1831. The diving-bell was swung four or five feet laterally in calm weather in these operations, much increasing their danger. Besides this, the guns and treasure were found covered by masses of rock of from thirty to fifty tons weight, moved by the action of the water, and weighed or turned over in the second operations by Captain De Roos.

From these facts, it was considered that floating breakwaters generally were not adapted to combat with the waves. Admiral Taylor's plan of timber frame-work sections; Captain Grove's iron cylinders with an attached grating; Captain Pringle's frame, moored by its lower edge; Captain A. Sleigh's floating sea-barrier; Mr. Smith's plan, as submitted to the Society, were mentioned; and it was considered that the calculations of their resistance were understated; that Admiral Taylor's section, instead of twenty-five tons' strain, might, if the waves exerted only one-third of their force as known, have to withstand upwards of 1,000 tons; this probably caused the failure of Admiral Taylor's experiment at Brighton, and Captain Groves's at Dover. Major Parlby's principle of the trumpet-mouth sea-weed was compared with the *fucus giganteus* of Dr. Solander, abundant on the Patagonian and Fuegian coasts, and 360 feet in length, which is carried under water in currents, and torn up, and chokes all the bays during storms.

The motion of shingle, an important consideration in establishing breakwaters, was shown to be governed by the direction in which the surf strikes the shore, and this is dependent on the direction of the wind. This, from fifteen years' observations by M. Nell de Bréauté, at Dieppe, was shown to be in the ratio of 229 days from western quarters to 132 days from eastern quarters, giving that preponderance to its eastward progress. The mode in which it was arranged on the sloping beach, in the form of a paraboloidal curve, was explained.

Sand, a more powerful agent than shingle in changing the character of a coast, was stated to be deposited by currents, thus rendering the eastern parts of the English Channel much more embarrassed by them than the western portion. The Goodwin Sands were exhibited as examples of the extent of accumulation, and the changeable character of sand deposits. The diagrams exhibited showed the progress of these alterations, and were drawn from, perhaps, the only authentic history we possess of the changeable character of a quicksand. The different periods, from Græme Spence's survey in 1795 down to Captain Bullock's in 1850, showed that they had shifted miles in their position and area, evidently refuting the practicability of any principle which would apply to fixing them, and rendering them available more perfectly for breakwater purposes, as was proposed by Captain Vetch, R.E., to the Royal Commission, 1845.

Mr. FINLAY commenced the second part of his paper by recapitulating some of the forces and circumstances to which breakwaters are subjected, as cited in the former abstract. The application of these was the subject of the present portion.

The preparations for the great Cherbourg *digue* were noticed; the proposals of 1712, and 1777, for a line of sunken ships filled with masonry, as at the siege of La Rochelle in 1573, and the first operations by M. de Cessart, in 1782-4, were described. This latter plan was to sink truncated conical caissons, strongly framed of timber, 150 feet diameter, and 64 feet high, floated by means of a double tier of immense casks around their bases. The first and second was successfully launched; but before the latter could be filled with stones, as intended, a storm carried it away to low-water mark. This led to a great change in the plan; instead of 90 of these cones tangent to each other, they were to be placed at considerable distances apart, the intervals to be filled with *pierre perdû*; 18 of them were laid, but they were all destroyed but one before 1789,—some of them in two days after their being placed. The method *à pierre perdû* was then resorted to, and continued with until it was modified by an upright parapet from low-water level by M. Dupare, 1832; the work is still in progress.

The series of four different slopes, in which the waves have distributed the stones of the *digue* was described; and the absence of the lowest slope in the Plymouth section was accounted for by the increased force of the waves upon the latter.

The commencement in 1811, by Mr. Rennie, and subsequent proceedings under its present superintendent, Mr. Stuart, of the Plymouth Breakwater, were then alluded to, and the increased length of foreshore which had been found necessary, from the original design, and the greater effect of the sea at its *west* end described. In 1838, from the great effects of a storm, a species of buttress was designed by Mr. James Walker, C.E., for the protection of the base of the lighthouse. This involved a new principle in hydraulic architecture, afterwards alluded to.

This structure resembles in some degree the system of dovetailing and grooves adopted by Smeaton in the Eddystone; but differs in its application. The Delaware breakwater in the United States was then briefly alluded to.

The principle of the presenting a concave face to the waves was then adverted to. In 1734, such a section was proposed, but not acted on, by M. Touros, for S. Jean de Luz. In 1787-95, Don Tornas Munos constructed the sea-walls of Cadiz thus: a straight foreshore of timber planking, and a curved masonry termination. This was destroyed by the blocks of stone placed at its foot for protection, rolling up the incline against the masonry. M. Emy, who endeavoured to establish the existence of what he denominates the *flôt-du-fond*, proposed a cylindrical, or other curvilinear face, for this purpose, in 1818, and in 1820 repaired the works of the fortification of St. Martin, Ile de Re, in the Bay of Biscay, on his plan, which was so far successful, though not very greatly exposed. Various forms of the concave *rèvetement* were noticed, and the natural form assumed by the shingle beach was cited as an instance of the effect of beach surf. This form has been adopted in the Dymchurch wall, constructed by Mr. Walker. The mode of action of the waves against a cliff was also explained, as producing a similar action.

Mr. Scott Russell's deduction from the wave system, leading also to similar conclusions, were then alluded to, and the sectional form he has proposed described. He preferred a paraboloidal curve for the foreshore; and an overhanging coping, so as to turn the wave on itself, was described. Mr. Russell, for deep water structures, preferred the method *à pierre perdû*, forming a straight foreshore. One objection to this system of concave face was, the varying level to which such structures are exposed by tidal influences, and the differences of curve presented at different periods of tide.

From these systems, the vertical, or nearly vertical wall, was then described; and the great national work at Dover, the Refuge Harbour, was stated to be on the principle established by the experience of the buttress at the west end of Plymouth breakwater. This mode of construction, found effective at that place, counteracts some of the difficulty met with in securing the masonry facing it. In a previous part of the paper it was stated that the stones were blown out of the facing, or towards the sea wave. This action is attributed to the percussive force entering the joints, and thus the water or air contained within the body of the masonry being most forcibly driven upwards and outwards, carried single stones out of their beds. The new mode consists of stepping one course of stones into the upper surface of that beneath it, so as to form a ledge to prevent its outward tendency, and also to divert the direct action of the wave on the joint. In addition to this, each stone is so dovetailed on its horizontal plane, that each course forms virtually one stone; and alternate stones in each course are locked into the course beneath it; so that, throughout the fabric, some portion of each course belongs to the one on either side of it, making the whole into one mass. These stones are found at the quarries, and fixed in their places by the diving-bell. The situation of Dover Harbour, as being free from the chances of silting up, was considered in reference to the tides, and the improbability that any great amount of shingle would for the future embarass the work.

NOTES OF THE MONTH.

Professional Jurisdiction.—In the inquiry before Mr. Cubitt, as Admiralty Inspector, on the Lea Navigation Bill, the East London Water Works Company claimed to be heard by counsel; and on the 25th, on the opening of the court, Mr. Merewether appeared to support their application on the threat of withdrawing altogether from the inquiry. Mr. Cubitt adhered to the determination he had expressed by letter, of hearing only engineers or solicitors; and this refusal having been recorded in his minutes, Mr. Merewether left the room. We hope Mr. Cubitt, and other engineers, acting in the like official capacity, will be equally firm, for there can be no reason, before such a tribunal, for the employment of barristers, who have to be instructed by engineers. Solicitors, are persons practically acquainted with the business of their clients. There can be no hardship on the Waterworks Company, for they could have adequate engineering assistance. The Board of Ordnance, who opposed, were represented by their solicitor and two government engineers; and most of the other opponents by engineers or surveyors. As a startling example of the mischiefs of employing non-practical men, we may refer to the celebrated Reading case, where many days were lost by the several batches of counsel.

Opening for Traffic of the Britannia Bridge.—On Friday and Saturday, the 15th and 16th ult. Captain Simmons, the Government Inspector for the Railway Commissioners, made his official inspection of this great structure, accompanied by Mr. Edwin Clarke, the resident engineer, and Mr. Hedworth Lee, the engineering manager of the Chester and Holyhead line, when a series of important experiments took place to ascertain the law of deflection, and the absolute structural strength of the fabric. The experiments consisted in observing the deflections under a series of successive loads; the passing of three locomotives, with a train sufficient to cover each of the tubes, through the bridge, at various speeds, and the running of locomotives and tenders through, without trains, at variable rates of progress. The first experimental Government train was a heavily laden one of coal wagons, weighing 240 tons, with three locomotive engines. This was run through the tube at the ordinary rate at which such trains travel, from 10 to 12 miles an hour, and the deflection, as taken by deflectometer, fixed in the centre tower, was scarcely perceptible. This train was then drawn completely over one of the tubes, and there left as a dead weight, while Captain Simmons descended and made a minute inspection of the masonry, the rivetting, plate-work, cellular top and bottom of the tubes, and other arrangements, which occupied a considerable time. On returning to the tube, the deflection caused by the load was found to be about three-fourths of an inch. Similar experiments made in the other tubes exemplified the perfect success that has attended the continuity of the beam—the most remarkable feature in the structure, caused by the junction of each of the before isolated tubes, for as the engines entered upon the small land tube the motion due to their progressive weight was ascertainable in every tube, even over to the further extremity of 1560 feet in length. Locomotives in steam were then passed through as fast as practicable, but only at 20 miles an hour, owing to the curves at either end. The deflection was the fraction of an inch, and the vibration scarcely perceptible, the tonnage weight of the tube itself acting in reality as a counterpoise or preventive to vibration. On the Monday following, the up express from Holyhead, carrying the mails and passengers from Ireland, came by the tube at a saving of a full hour over the usual transit. The subsequent trains to and fro also went through both ways. All the arrangements for this purpose are now permanently complete, and the floating of the twin tubes for the parallel line is occupying the attention of the engineers.

Improved Covering for Railway Wagons, to supersede the cumbersome and loose tarpaulin, has been patented by Mr. Rowland Brotherhood, of Chippenham. It allows of a small or large portion, or the whole area of the truck, to be exposed; one porter can uncover two trucks in the space of a minute, and two can re-cover them in the same time. It consists of a fan of seven ribs, placed at each end of the truck, connected in pairs by a horizontal bar to each over the top of the truck; this fan is covered with prepared water-proof canvas, and is opened and inclosed with as much facility as the head of a cabriolet or landau, on which principle it is constructed. It affords great facility for loading and unloading goods; can be secured by locks and keys. It has been in use all the winter on the Great Western line with much satisfaction.

Improved Manufacture of Peat Charcoal.—Although numerous have been the attempts to produce a charcoal from peat, fit for all, even the most delicate metallurgical purposes, and although several patents have been obtained within the past few years for particular methods of manipulation, success has not yet appeared to have crowned our efforts in this country. While these attempts have been made in vain in England and Ireland during the past ten years, Mr. Vignoles, the well-known railway engineer, during his professional duties on the continent, discovered that a process for converting peat into charcoal or coke, had been most successfully carried out in Germany for some years past. He accordingly availed himself of the opportunity, and having made himself master of all the details of the process, has taken out a patent for Irelanu, from the specification of which we extract the following particulars:—The peat is subjected to a certain high temperature, in such manner as to deprive it of the whole, or a principal portion, of the water which it naturally contains. This heat is then continued under peculiar circumstances until the peat is converted into charcoal or coke. One of the most important properties of the process is, that by the mode adopted of applying the heat the substance is not burned to ashes and wasted. In the first part of the process, the peat or turf extracted from the bog by any of the usual methods, is dried in pieces of any convenient size, either by exposure to sun and air, or to artificial heat, and afterwards placed in an iron vessel of large capacity, called the "carbonising vessel." Steam, generated in any form of boiler, with a pressure of from 45 lb. to 60 lb. per square inch or upwards above the atmospheric pressure, is passed through a number of tubes of iron, heated to a bright red heat, by being placed in a suitable furnace, so that without losing its pressure it acquires additional temperature up to 450° or 460 Fahr., or about the melting point of tin or lead. This part of the apparatus is called the "coil," the surface of which should be nicely proportioned to the generating power of the boiler. The steam thus highly heated is permitted to pass into the "carbonising vessel" containing the partially dried peat, and the effect is rapidly to withdraw any moisture which may remain, in the state of steam, from the peat; the whole of the steam from this vessel is allowed to escape, and may be advantageously used as a motive-power, for preparatory desiccation of the turf, or for any other purpose. After this drying process has gone on until the peat or turf has parted with nearly all its moisture, it begins to be charred or carbonised by the high-pressure steam, and in proportion as the dehydration of the peat advances, so does the temperature of the carbonising vessel increase, until it approaches closely to that of the steam in the coil, which must be sufficiently high for the perfect decarbonisation of the peat. The process is continued until the turf is found reduced to a black substance, retaining the forms nearly of the original masses, but now almost a perfect vegetable charcoal or coke.

Dr. Potts.—Dr. Lawrence Holker Potts died on the 23d of March, at the age of 60. He was the patentee of the system of hydraulic piledriving, which is applied on the Chester and Holyhead, Windsor, Great Northern, and other railways. He was likewise the inventor of a process for preserving animal substances. His mechanical genius showed itself even when a boy at Westminster school, in constructing an electrical apparatus from a quart bottle, and like rude materials; and as it afterwards influenced his professional pursuits, having distinguished himself very much in the application of mechanical contrivances to the treatment of spinal diseases. Dr. Potts was a native of London, but practised long at Bodmin; and was the founder of the Royal Cornwall Polytechnic Society.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM FEBRUARY 23, TO MARCH 20, 1850.

Six Months allowed for Enrolment, unless otherwise expressed.

Charles Andrew, of Compstall-bridge, Chester, manufacturer, and Richard Markland of the same place, manager, for certain improvements in the method of, and in the machinery or apparatus for, preparing warps for weaving.—Sealed February 21.

James Hall, of Geecross, near Stockport, Chester, machine maker, for certain improvements in looms for weaving.—February 25.

Brereton Todd, of the Bank, Falmouth, gentleman, for improvements in the manufacture of arsenic, sulphuric acid, and the oxide of antimony, from copper and other ores, in which they are contained, and also the oxide of zinc.—February 27.

George Gwynne, of Sussex-square, Middlesex, esquire, for improvements in the manufacture of sugar.—February 27.

Matthew Cochran, of High-street, Paisley, Renfrew, North Britain, manufacturer, for improvements in machinery for the production and ornamenting of fabrics and tissues generally, parts of which are applicable to the regulation of other machinery, and to purposes of a similar nature.—February 27.

Julius Jeffreys, of Bucklersbury, City of London, gentleman, for improvements i pre venting or removing affections of the chest.—February 28.

George Tosco Peppe, of Great Marylebone-street, Middlesex, civil engineer, for im provements in time-keepers.—February 28th.

George William Lenox, of Billiter-square, City of London, chain cable manufacturer, and William Roberts, foreman to Messrs. Brown, Lenox, and Co., of Millwall, for improvements in working windlasses and other barrels —February 28.

Thomas Richards, William Taylor, and James Wylde, the younger, all of Falcon Works, Walworth, Surrey; cotton manufacturers, for improved rollers to be used in the manufacture of silk, cotton, woollen, and other fabrics.—March 2.

William Edwards Staite, of Throgmorton-street, City of London, gentleman. for improvements in pipes for smoking, and in the apparatus connected therewith.—March 4.

William Mac Naught, of Rochdale, Lancaster, engineer, for certain improvements in steam-engines; and also in apparatus for ascertaining and registering the power of the same.—March 7.

John Fowler, jun., of Melksham, Wilts, engineer, for improvements in draining land.—March 7.

William Benson Stones, of Golden-square, Middlesex, Manchester warehouseman, for improvements in treating peat, and other carbonaceous and liqueous matters, so as to obtain products therefrom. (A communication.)—March 7.

Henry James Tarling, of Bayswater, Middlesex, commission agent, for improvements in the manufacture of fuel and manure, and deodorising and disinfecting materials.—March 7.

William Brown, of Airdrie, Lanarkshire, electrician, and William Williams, the younger, of St. Dennis, Cornwall, gentleman, for improvements in electric and magnetic apparatus for indicating and communicating intelligence.—March 7.

Ebenezer G. Pomeroy, of Cincinnati, Ohio, United States, chemist, for a new and useful process of coating iron, and other metals, with copper and other metallic substances.—March 7.

William Church, of Birmingham, engineer, for certain improvements in machinery or apparatus to be employed in manufacturing cards, and other articles, composed wholly or in part of paper or pasteboard; part or parts of the said machinery being applicable to printing the same; and other purposes where pressure is required.—March 7.

Richard Archibald Brooman, of the firm of Messrs. J. C. Robertson and Co., of Fleet-street, for improvements in types, stereotype plates, and other figured surfaces for printing from. (A communication.)—March 7.

Richard Carte, of Southampton-street, Strand, Middlesex, professor of music, for certain improvements in the musical instruments designated flutes, clarionets, hautboys, and bassoons.—March 7.

John Taylor, of Manchester, mechanical designer, and Richard Hurst, of Rochdale, cotton spinner, for certain improvements in, and applicable to, looms for weaving, and in machinery or apparatus for preparing, balling, and winding warps or yarns.—March 7.

Gerard John de Witte, of Brook-street, Westminster, Middlesex, gentleman, for improvements in machinery, apparatus, metallic, and other substances, for the purposes of letter-press and other printing. (A communication.)—March 7.

John Tebay, of Hackney, Middlesex, civil engineer, for an improved meter, for registering the flow of water and other fluids.—March 7.

Frederick Rosenberg, of Albemarle-street, Middlesex, esquire, and Conrad Montgomery, of the Army and Navy Club, Saint James's-square, in the same county, esquire, for improvements in sawing, cutting, boring, and shaping wood.—March 7.

Thomas Irvine Hill, of Clapham, Surrey, gentleman, for certain improvements in the treatment of copper and other ores, and obtaining products therefrom.—March 9.

Richard Holdsworth, of the firm of Holdsworth and Co., cotton spinner, and William Holgate, engineer, for improvements in apparatus and machinery for warping worsted, cotton, and other fibrous materials.—March 11.

William Crane Wilkins, of Long Acre, Middlesex, engineer, for certain improvements in ventilating, lighting, and heating in lamps and candlesticks; in the manufacture of candles; and in the apparatus to be used for such purposes.—March 11.

James Nasmyth, of Lille, France, engineer, for improvements in the method of obtaining and applying heat.—March 12.

Robert Milligan, of Harden, near Bingley, York, manufacturer, for an improved mode of treating certain floated warp or weft, or both, for the purpose of producing ornamental fabrics.—March 18.

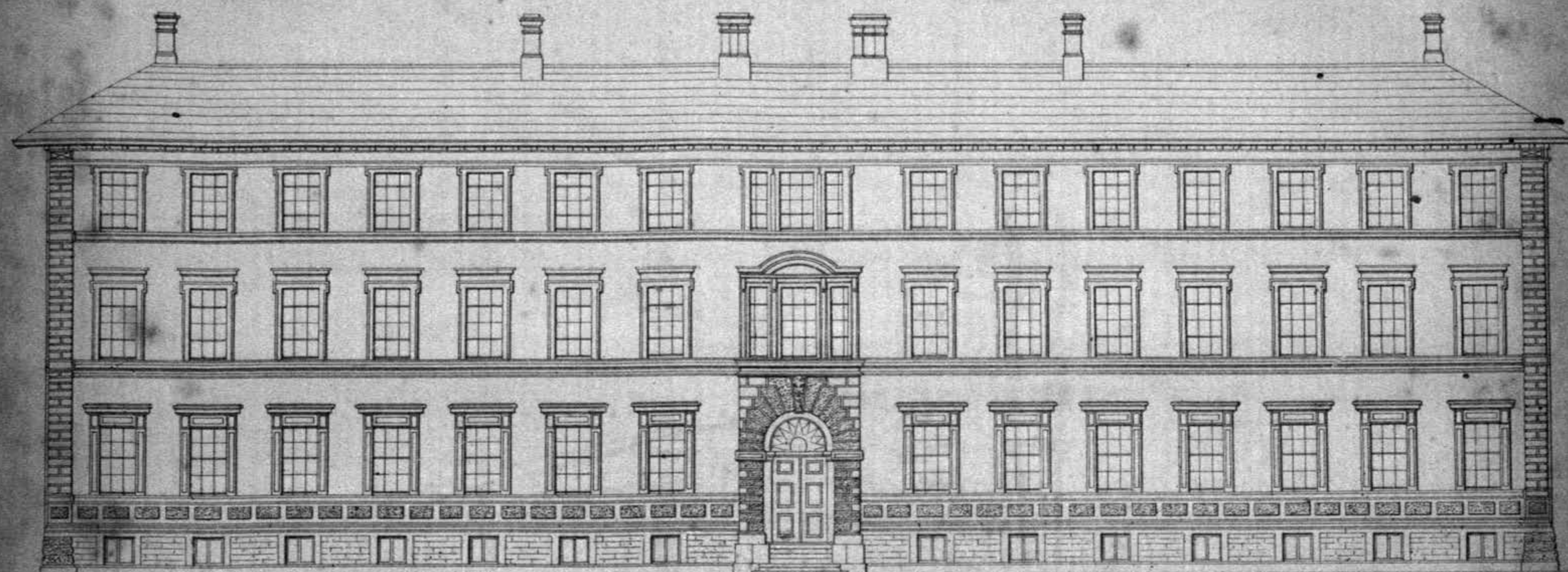
George Jenkins, of Nassau-street, Soho, Middlesex, gentleman, for certain improvements in the means of producing motive power.—March 18.

Thomas Edmondson, of Salford, Lancaster, printer, for improvements in the manufacture of railway and other tickets; and in machinery or apparatus for marking railway and other tickets.—March 19.

William Joseph Horsfall, and Thomas James, both of the Mersey Steel and Iron Works, Toxteth Park, Liverpool, Lancaster, for improvements in the rolling of iron, and other metals.—March 19.

Samuel Cunliffe Lister, of Manningham, near Bradford, York, and George Edmund Donisthorpe, of Leeds, in the same county, manufacturer, for improvements in preparing and combing wool and other fibrous materials.—March 20.

Pl. 8



YORK COUNTY HOSPITAL

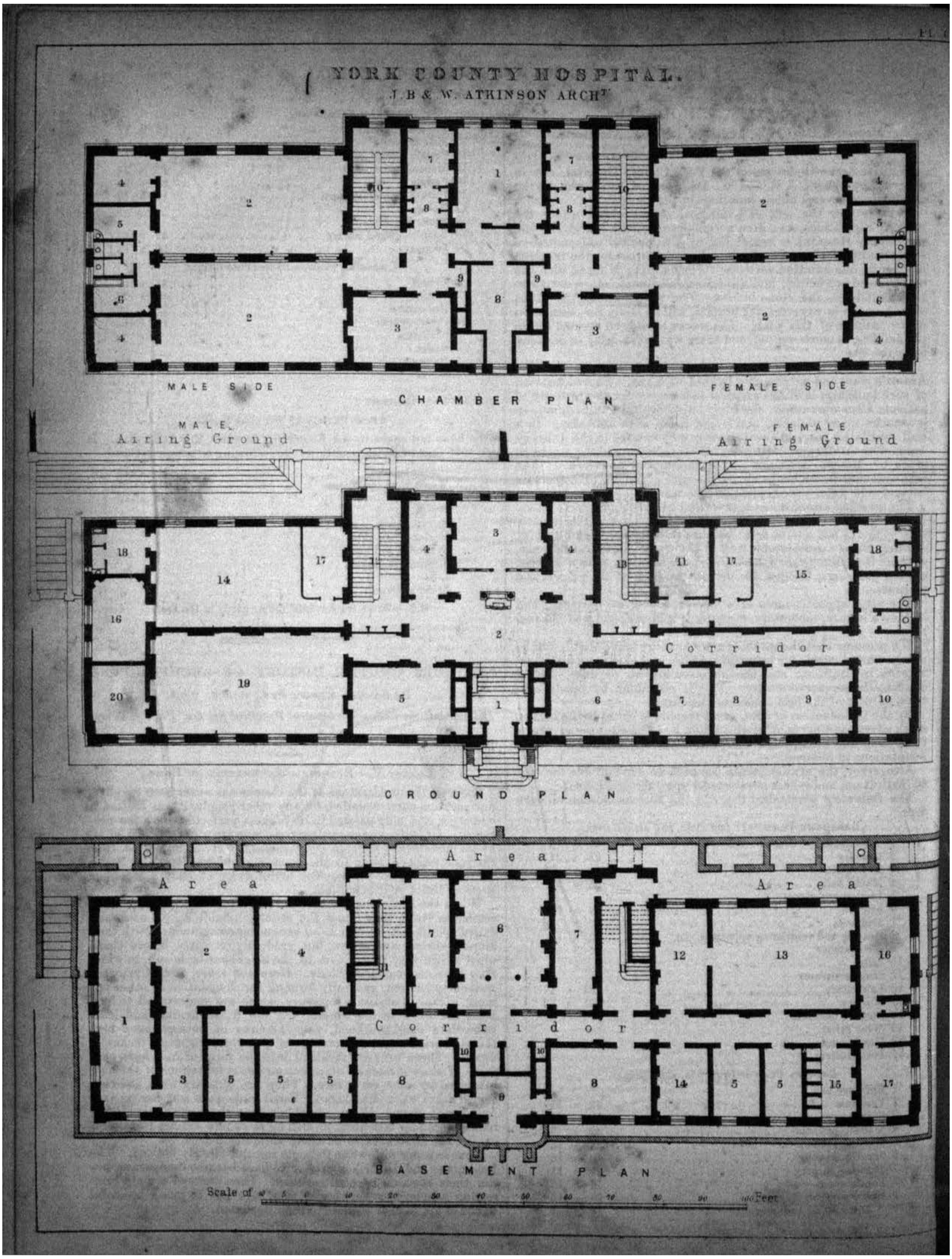
PRINCIPAL FRONT

188 Feet

SCALE

J. B. & W. Atkinson Arch^ts York 1849

J. R. Jobbins


YORK COUNTY HOSPITAL.
J. B & W. ATKINSON ARCHTS
MALE SIDE
CHAMBER PLAN
FEMALE SIDE
MALE
Airing Ground
FEMALE
Airing Ground
Corridor
GROUND PLAN
Area
Area
Area
Corridor
BASEMENT PLAN
Scale of 10 5 0 10 20 30 40 50 60 70 80 90 100 Feet

YORK COUNTY HOSPITAL.

Messrs. J. B. and W. Atkinson, of York, Architects.

(*With Two Engravings, Plates* V. *and* VI.)

We give herewith designs of the York County Hospital, now in progress, by Messrs. J. B. and W. Atkinson, of York, who are the architects of several public buildings in the county.

York is now the seat of a medical school which, under the modern regulations, can give a complete medical education; and the County Hospital is recognised by the medical universities as an institution for practice, having accommodation for the required number of one hundred patients. The building is faced with the best pressed red bricks, and has a stone basement, stone dressings to the windows, and stone quoins. The total cost will be about 9000*l.*; and it is expected the hospital will be ready for occupation in the autumn of this year. The works have been pressed on, as the building is much wanted, and there was great delay in deciding upon the site.

The hospital is to be heated and ventilated throughout on Dr. Arnott's plan, and we presume lighted with gas. The ventilation of such buildings is of the greatest importance for the recovery of patients after operations, for when once hospital gangrene sets in it attacks many patients, and is got rid of with difficulty. In a well ventilated hospital fever cases can be treated in the ordinary wards without danger. We are glad therefore to see the attention given by Messrs. Atkinson to the sanitary arrangements. The bath accommodation is shown on the plans, and we presume that hot and cold water are supplied to each ward.

The washing establishment, it will be seen, occupies some space, including a washhouse, laundry, and drying closet. The importance of this is not seen at first; but the truth is, the expenditure for washing forms a considerable item of the whole yearly expenditure, as there is such extensive use of linen for bedding, patients' wear, and for dressings, besides the private washing of the officers and servants.

The usual appurtenances of a medical school are provided, and include a library, laboratory, museum, deadhouse, and post mortem room.

We presume that the establishment is so arranged that it can be yearly whitewashed, an operation which is found most beneficial in such institutions; and though entailing an expense, adding much to the sanitary security. This is now done by yearly contract in most of the best conducted hospitals.

By the introduction of lifts, great trouble is saved to the nurses, much of whose time is otherwise taken up in the supply of provisions from the kitchens for the patients' meals, while there is less temptations to idleness.

Altogether, the arrangements are such as are suitable for such an institution, and reflect great credit upon the architects.

The following particulars describe the accommodation on each floor.

Basement Plan.—11 feet clear, and arched over.

1	Washhouse	47 × 12
2	Laundry	23 × 21
3	Drying closet	23 × 9½
4	Maids' hall	23 × 21
5	Larders and stores	
6	Kitchen	30 × 19
7	Sculleries	30 × 9½
8	Heating and ventilating apparatus, &c.	22 × 16
9	Air chamber	
10	Lifts	
11	Stone staircases	
12	Laboratory	23 × 11
13	Museum	31 × 23
14	Porter's bedroom	
15	Wine cellar	
16	Dead house	
17	Post mortem	

Ground Plan.—14 ft. 6 in. clear height.

1	Entrance hall	
2	Vestibule	42 × 13½
3	Dispensary	19 × 16
4	Waiting patients	22 × 9½
5	Physicans' room	22 × 16
6	Surgeons' room	22 × 16
7	Dressing surgery	16 × 11
8	Pupils' room	16 × 10½
9	House surgeon	20 × 16
10	Ditto bedroom	16 × 12

Ground Plan (*Continued*).

11	Matron's parlour	16 × 11
12	Male staircase	11 wide
13	Female do.	11 wide
14	Male accident ward	23 × 34
15	Female do.	23 × 23
16	Private separation ward	18 × 12
17	Nurses	
18	Sculleries, &c.	
19	Boardroom and library	42 × 23
20	Secretary	16 × 12

Chamber Plan.—15 feet clear height.

1	Chapel	21 × 19
2	Wards	42 × 23
3	Day-rooms	22 × 16
4	Private wards	16 × 12
5	Sculleries	
6	Baths	
7	Nurses	
8	Stores	
9	Lifts	
10	Stone staircases	

Attic Plan.—15 feet clear height.

[We have not space in our Engraving to show the Attic plan. It is 15 feet high, and contains the following accommodation.]

1	Operation room	21 × 19
2	Wards after operations	21 × 9½
3	Foul wards	22 × 16
	Wards	
	Private wards	
	Nurses	
	Sculleries and baths	
	Matron's bedroom	
	Lifts	
	Stone staircases	

N.B.—There are servants' rooms partly in the roof.

LECTURES ON THE HISTORY OF ARCHITECTURE:

By Samuel Clegg, Jun., M.I.C.E., F.G.S.

Delivered at the College for General Practical Science, Putney, Surrey.

(PRESIDENT, HIS GRACE THE DUKE OF BUCCLEUCH, K.G.)

Lecture V.—Etruria.—Foundation of Rome.

Though the architecture of the Greeks has never been excelled, nor perhaps even equalled, by any other people, it was limited to one style, and only existed in its highest perfection for a few centuries. In Italy, on the contrary, we may trace the history of art by its monuments, through every successive style and period, from the rude unhewn altar to the completion of St. Peter's at Rome. It is, however, to the ancient architecture of Italy I would at present direct your attention.

When the Umbrians, Pelasgians, and afterwards the Etruscans, settled in Italy, they found the country inhabited by a wild race, called the Siculi or Sikeli. These never amalgamated with their more civilised conquerors, but gradually retreated before them, until at last they passed over to the neighbouring island, to which they gave the name of Sicily. Here and there, rude Cyclopean walls may be seen, generally forming the foundation of other and more advanced styles of masonry, which are conjectured to have been the work of the Sikeli. On the Alban mount, and in its immediate neighbourhood, singular urns of pottery have been found, buried under a stratum of peperino, eighteen inches in depth. These urns are moulded into the form of rude huts, as if made of skins stretched on poles, no doubt imitations of the huts inhabited by some early race. They are cinerary urns, and contained ashes when discovered. Small rude pots and lamps were found with them. When we think that these urns were lying imbedded under a stratum formed by some now extinct volcano, it carries the mind back to a remote antiquity indeed.

Next in order follow the Pelasgic remains already noticed. The Pelasgians and Umbrians appear to have been contemporary, nor can their remains be distinguished. Then succeed a more interesting people, the Etruscans, who have left so many beautiful works of art to bear witness to their dominion.

The name by which the Etruscans always called themselves was Rasena. That by which they were known amongst the Greeks was Tyrseni, or Turrheni; but as the Umbrians and Pelasgians in Italy were also called Tyrrhenian, it has given rise to some confusion.

Authors differ greatly as to whence the Etruscans came, or how far their dominion actually extended. In fact, we only know enough of them to excite our curiosity, without much hope of ever having it satisfied. Notices of the Etruscans are only scattered here and there in the Latin writings, nor can these cursory remarks always be relied upon.

Micali says, "It is easy to understand how, during a period when the passion for war was all-absorbing, the proud and barbarous indifference of the Romans despised the knowledge of a rival people, with whom they had so long disputed pre-eminence and the empire of Italy." But there is little doubt that the Romans not only despised, but wantonly falsified and destroyed the records and monuments of Etruria; and this has hitherto been an irreparable evil, as the Etruscan language entirely differs from any now known, so that the inscriptions on the tombs are but a dumb treasure.

But who shall place a limit to the discoveries of this age of energy and enlightenment? And when we remember how short a time it is since Dr. William Young first discovered the key to the hieroglyphics, and that within the last few months some light has been thrown on the cuneiform character of Assyria, we need not despair of being enabled at some future time to decypher the few remaining records of Etruria.

Though some authors advocate a different opinion, there seems every reason to believe that the Etruscans were of Eastern origin. Their religious forms and ceremonies, their architecture and style of masonry, all seem to denote this. According to Micali, "The Tuscan name filled with its glory all the country from the Alps to the Sicilian straits;" but their empire must soon have been confined to Etruria Media, as between 900 and 1000, B. C., we find the names of Ænotrians, Volscians, Latins, and others, as separate states: whether tributary or not is uncertain.

Long after this, however, and long after the foundation of Rome, the Etruscans continued "lords of the sea;" for out of respect to their power, the one sea was called Tuscan, the other Adriatic, from their great city Adria. They sent out colonies even as far as the coast of Spain, where they founded Tarraco, now Tarragona; and thus keeping up intercourse with all the nations bordering on the Mediterranean, wealth flowed into their country, and art and science followed in the train of commerce.

Etruria Media, or Etruria Proper, comprehended what is now the duchies of Tuscany and Lucca, the Papal States north of the Tiber, and extended across from sea to sea. The government was eminently favourable to the rise of art. It was aristocratic and federal; divided into twelve districts, under the names of the twelve principal cities, Tarquinii, Veii, Falerii, Cære, Volsinii, Vetulonia, Rusellæ, Clusium, Arretium, Cortona, Perusia, and Volterræ. Each of these cities was ruled by a chief lucumo, or king. Lars Porsenna was called King of Clusium. Tarquinii was the capital city of the kingdom; and in this district was the seat of the great national council, Voltumna. Thus these cities were independent, though united, and naturally vied with each other in producing noble works of art. The firmness of the government also tended to the cultivation of the elegancies of life; for Etruria changed neither name, language, laws, nor religious forms during the whole period of its existence, retaining the latter even after its subjugation to Rome.

In the north of Etruria the higher mountains are of limestone, and the lower range of sandstone. The southern district is almost entirely volcanic tufa, lava, and scoriæ, with occasional basalt or limestone peaks, like Soracte, overtopping the lower volcanic hills. Consequently the masonry of north and south Etruria differs considerably. Owing to the greater difficulty of working the limestone and sandstone, the blocks were seldom cut to a size, though generally squared and laid in horizontal courses. In the south, where the stone was of a softer nature, and more easily worked, the masonry was beautifully regular. The Etruscans seldom, if ever, used cement, but relied entirely upon the bond of their work. In some instances layers of thin bricks or tiles were laid between the courses of stone. Rustic work was also frequently used by the Etruscans.

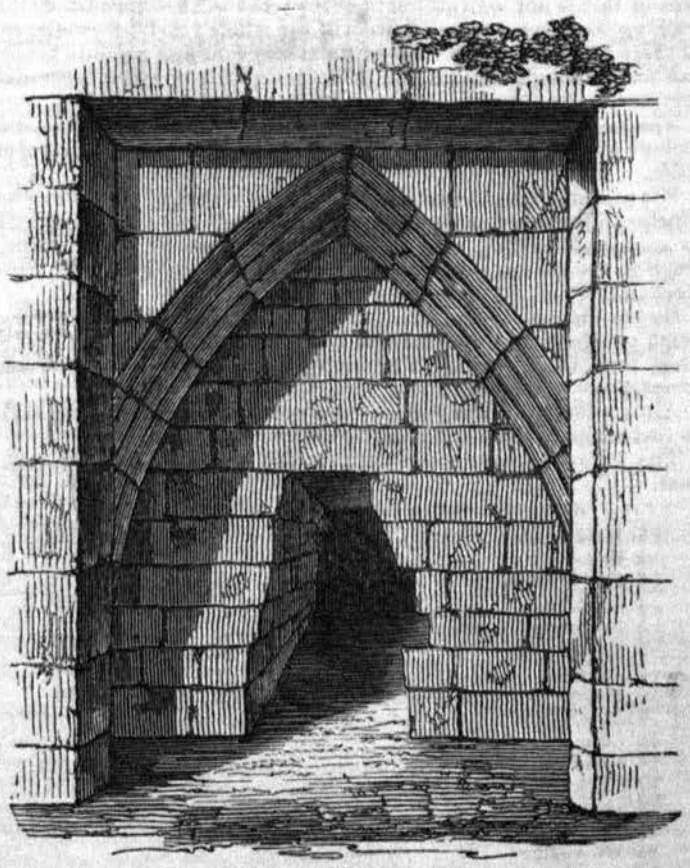
In part of the wall of Volterræ and elsewhere, the upper are much more massive than the lower courses, and are supposed to have been placed thus, that the larger stones might be opposed to the stroke of the battering ram.

The situation of Etruscan towns announces a greater degree of social security than was enjoyed by the Pelasgians or Umbrians. In the volcanic district the ground is split into ravines, each forming a sort of natural fosse. A piece of land lying between two such ravines was a favourite site with the Etruscans on which to erect their cities. In the north the towns were situated on an eminence, but not at such an unattainable height as the cities of the earlier settlers. Each city was surrounded by a massive wall, and guarded by square towers, usually about fifty feet apart.

Sir William Gell, in his description of the ancient Fescennium, says that about sixty towers yet remain standing. They have chambers in the upper story, with doors opening from them on to the wall, so as to allow of an uninterrupted passage along the ramparts. Each city had its citadel or arx, its temples, theatre, amphitheatre, baths, and other public buildings, remains of which may yet be traced. Each city had also a complete system of sewerage, by which the extent of these towns of ancient Etruria may be seen.

Etruria Proper was at one time so densely populated that there were walled towns, occupying many square miles, and containing several thousand inhabitants, within two miles of each other. Now, with few exceptions, these great cities are laid low. Perhaps a modern Italian village occupies a corner of the ancient site; but more frequently the spot is a wilderness, where the shepherds pasture their flocks, or a desolate swamp, where the demon malaria holds undisputed possession.

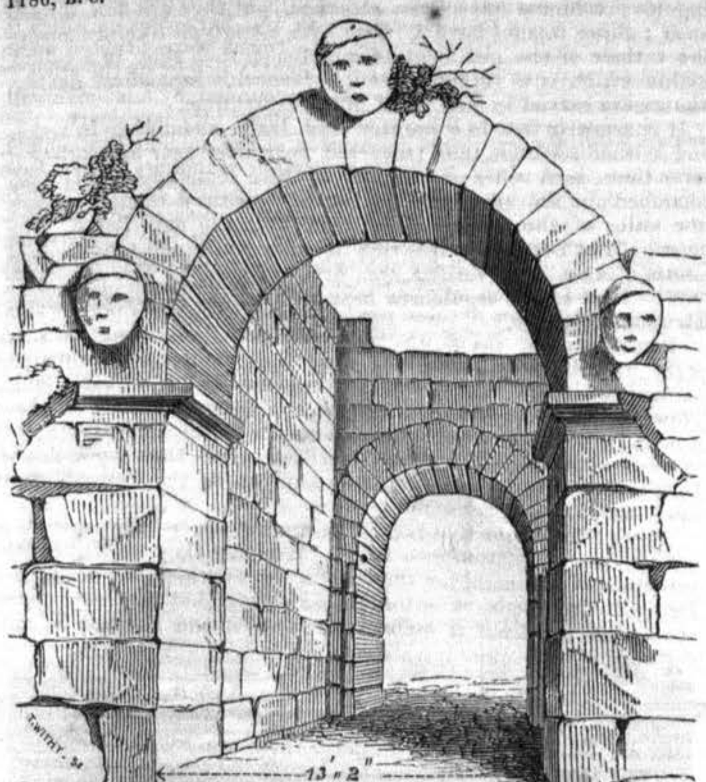
There is no doubt that the Etruscans introduced the principle of cuneiform sustentation into Italy. Whether they worked out the principle of the arch for themselves, or whether they acquired it from the Egyptians, it is impossible to say; but that they understood and practised it before the time of the Romans is quite certain.



Etruscan Emissarium.

It is singular that when they had once discovered this principle, they did not always practice it; but it seems they only applied it to great public works, and in other places still made use of the old Pelasgic methods. Many of their arches are formed by the courses of stone projecting one over the other; and in the emissarii, or grottoes at the embouchure of the water conduits, the pointed arch, constructed with flat stones meeting at an angle, is frequently met with. There is an uncemented arched cloaca at Graviscæ, the voussoirs of which are from five to six feet in depth; but the Porta all' Arco, at Volterræ, is considered the oldest and most perfect Etruscan archway now in existence. It has been a consecrated gateway, for the heads of the three divinities are placed above the

imposts, and upon the keystone. It is generally believed to have been built 600 or 700, B. C.; but tradition gives it as early a date as 1186, B. C.



Porta all' Arco, at Volterræ.

Mr. Dennis, in his valuable work on Etruria (speaking of the Porta all' Arco), says "I envy the stranger his first impression on approaching this gateway: the loftiness of the arch; the boldness of its span; the massiveness of its blocks, dwarfing into insignificance the mediæval masonry by which it is surrounded; the venerable, yet solid, air of the whole; and, more than all, the dark, featureless, mysterious heads around it, stretching forwards as if eager to proclaim the tale of bygone races and events; even the site of the gate, on the very verge of the steep, with a glorious map of valley, river, plain, mountain, sea, headland, and island, unrolled beneath, make it one of the most imposing, yet singular, portals conceivable, and fix it indelibly on his memory."

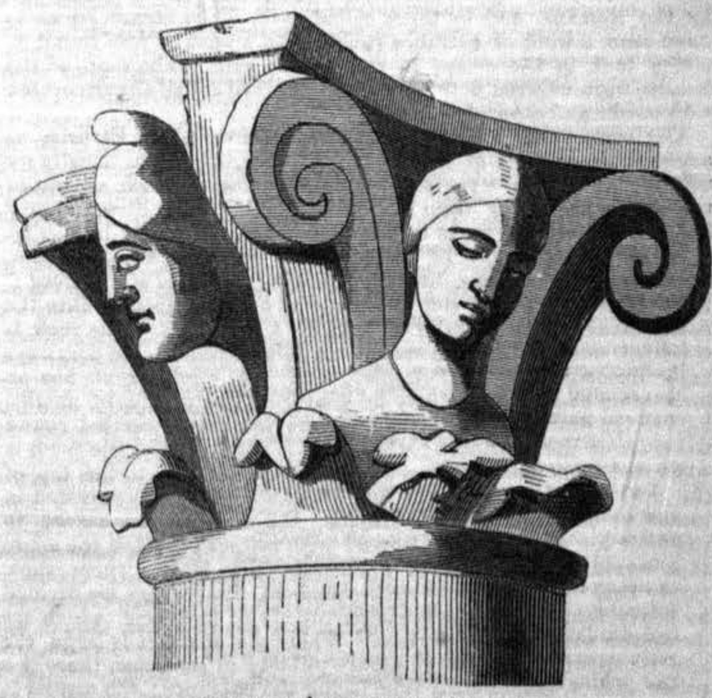
It is a double gateway; the total depth about 27½ feet; the span of the arch is 13 ft. 2 in.; the height to the keystone, about 21½ feet. There is a groove for a portcullis; or, as the ancients called it, a *cataracta*, which was suspended by iron chains within the gate. Similar grooves or channels are found in all the old double gateways in Italy. According to Mr. Dennis there is a cinerary urn, found in the cemetery of ancient Volterræ, on which is figured Capaneus struck by lightning while scaling the gate of Thebes. The gate represented on the urn is an exact copy of the Porta all' Arco, with the three heads on the imposts and keystone.

The three principal divinities, Tina, Talna (or Jupiter and Juno), and Minerva were the only deities to whom temples were erected within the city walls. The ground plan of the temple was divided into six parts for the length, five being given to the width. The length was then divided into two equal parts, one of which was for the cellæ, and the other for the vestibule, or portico. The width was divided into ten parts; three parts on each side were given to the smaller cellæ, and four to the centre, or principal cella. These cellæ were sometimes separated by walls, sometimes only by columns, like a nave with side aisles. The principal altar was in the centre cella, answering to the high altar in Catholic churches. The lateral walls of the temple terminated in antæ; the columns at the angles were placed opposite the antæ, and far enough distant to admit of another in the interval. The two other columns in front were placed in the line of the walls separating the cellæ.

The following are the proportions of the Tuscan column, as given by Vitruvius. "The columns are to be seven diameters high, their height one-third the width of the temple; the diminution of the shaft one-fourth of the lower diameter; the bases half the lower diameter; and divided in height into two parts, the lower for the circular plinth, and the upper for the torus and apophyge. The height of the capital to be also half the lower diameter; the greatest extent to be equal to twice the height. The plinth, corresponding to the abacus in other orders, is to be one-third the height of the capital, the echinus one-third, and the hypotrachelium with its apophyge one-third." The intercolumniation was areostyle; the architrave was formed of beams of wood, placed one upon another, the height being according to the magnitude of the temple; the beams were joined together by cramps and dovetails; the mutules projected one-fourth of the height of the column, both beyond the architrave and the lateral walls of the temple. The tympanum was constructed either of masonry or timber, and was ornamented with figures in terra-cotta, or gilt bronze.

The ancient Etruscan column probably differed from the Tuscan order as laid down by Vitruvius, and was most likely merely a modification of the ancient Doric derived from Phœnicia. The Greek Doric had no base, because the columns having to support a heavy stone entablature, the intercolumniations were necessarily narrow, and a base would have been inconvenient: but a base was not an unnatural addition. In wooden structures it would be a slab placed below the pillar, to preserve it from the damp of the ground; and was introduced into the Tuscan order, where the intercolumniations were wide, the columns only having to support a wooden epistylium. The Tuscan temple is the simplest and most primitive, the wooden building being as yet only partly exchanged for stone; the mutules are exact imitations of projecting beam ends, without even an attempt at ornament. There was no frieze in the Tuscan order, and the shafts of the columns were never fluted. The whole structure is low and imposing.

At Albano, there are some few fragments of the Tuscan temple of Jupiter Latialis, built by Tarquin the Proud. They were found when the Convent dei Passionanti was built upon its site, and nearly correspond with Vitruvius's description of the order. The sacred architecture of Etruria was more under religious constraint than that of Greece; but if they had one undeviating plan and order for their temples, they, like the Egyptians, allowed their fancy full scope in decorating their tombs and other structures. Capitals have been found in various parts of Etruria, bearing some resemblance to the early Norman, with heads intermixed with volutes and foliage. These are not supposed to be very ancient, and may probably be dated near the fall of Etruria.



Etruscan Capital, found at Toscanella.

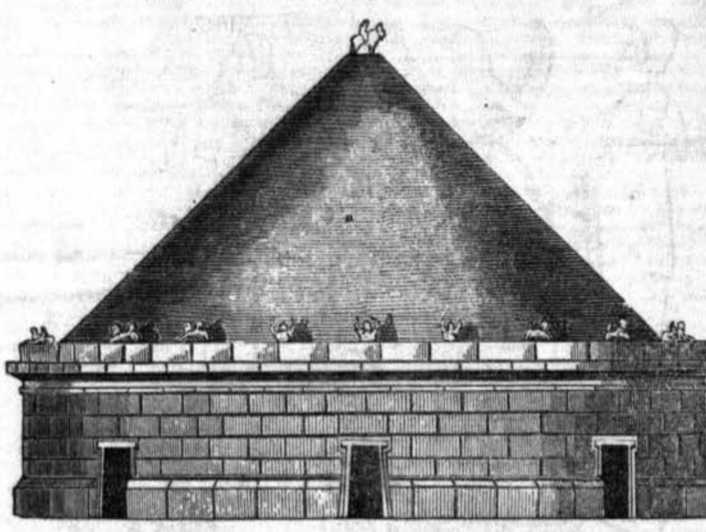
The amphitheatre, with its gladiatorial games, originated with the Etruscans. The Romans imitated these sports, and rendered them still more ferocious by an infusion of their own warlike spirit. It was thought beneath the dignity of a lucumo to join in any public trial of strength or skill; so instead of the refined contests of the Greeks in music, poetry, and athletic exercises, the Etruscans obliged their slaves to combat in the arena, for the amusement of

their indolent and luxurious masters. The word amphitheatre is derived from the Greek, and signifies a place formed of two theatres (*amphitheatroi*), or the parts of two circles united, the usual form being an ellipse. The seats were arranged entirely round the arena, so that the spectators could see equally well from all parts of the building. It was appropriated to gladiatorial games, wild beast fights, and similar spectacles.

An Etruscan amphitheatre was discovered at Sutri, by the Marquis of Savorelli, only twelve years ago. The ground is now cleared of rubbish, and the trees removed by which it was overgrown. The plan is somewhat irregular, being carved out of the rock, and the seats and passages formed according to the natural surface. The arena is 164 feet in length, and 132 feet in its greatest breadth. A vaulted corridor surrounds it, into which access is gained by doors in the podium. The seats rise from the podium, or low wall surrounding the arena. To continue the description in the words of Mr. Dennis: "At the interval of every four or five (speaking of the rows of seats), is a prœcincto, or encircling passage, for the convenience of the spectators in reaching their seats. There are several of these prœcinctiones, and also a broad corridor above the whole, running round the upper edge of the structure. On one side, above the upper corridor, rises a wall of rock, with slender half-columns carved in relief on its face, and a cornice above. In the same wall or cliff are several upright niches, perhaps for statues of presiding gods. Another peculiarity in this amphitheatre is a number of recesses, about half-way up the slope of seats. There are twelve in all, but three are vomitories, and the rest are alcoves, slightly arched over, and containing each a seat of rock, wide enough for two or three persons, probably intended for the magnates of the town. At the southern end is a vomitory on either side of the principal entrance; at the northern on one side only of the gateway. The vomitories have grooves or channels along their walls, to carry off the water that might percolate through the porous tufa. This feature is frequently observed in the rock-hewn sepulchres and roads of Etruria. The vomitories contain flights of steps, separated by landing places. The entrance passage is hewn into the form of a regular vault, sixteen or seventeen feet high, and about the same in width: its length is sixty-eight feet." This is an interesting ruin, showing us the model from which the Romans copied. Of Etruscan domestic architecture we know little, except from the imitation of dwelling-houses in the tombs. Servio, in speaking of Adria, says that the houses had large open vestibules, which were afterwards imitated by the Romans, and by them called atrii. The atrium seems to have been a kind of entrance court, with a pent or roof round it, and a tank in the centre to receive the rain. The roofs of the houses were covered with coloured tiles, and fancifully decorated with masks and other devices.

The same taste for tomb decoration prevailed in Etruria, as amongst the nations of the East. The necropolis was usually on the opposite side of a ravine, or stream of water, which separated the city of the living from that of the dead. Each Etruscan city had some peculiarity in its mode of sepulture, depending in a great measure on the nature of the ground. Castel d' Asso, Norchia, Bieda, and Sovana, are, literally speaking, "cities of the dead;" the low cliffs on either side the roadway being sculptured into the resemblance of the exterior of temples and houses. The rock is chiselled smooth, and the ornaments left in relief; the doorways taper inwards like the Pelasgian, and the whole front has an inclination backwards, as may be seen from the profiles of mouldings in the drawing: the mouldings are frequently carried round the sides of the sepulchre; where this is not the case, one tomb is separated from another by a flight of steps leading to the top of the cliff. In the interior, the sepulchres are generally excavated in imitation of constructed dwellings; the ceilings are carved to resemble low pitched roofs, formed with rafters placed at the angle that would be necessary in a climate like Italy, where snow rarely lies. In some of the rock-chambers, the ceilings are divided by heavy beams into square compartments or lacunaria, which are decorated with painted devices. When the chamber is large, the roof is supported by massive square pillars; at Bomazzo, there is a pillar with a semicircular side facing the entrance; the capital is a square block bevelled off towards the shaft. The sarcophagi, on which the dead recline as if at a banquet, are ranged along the wall: when benches of rock are left to receive the bodies, they are carved into the exact resemblance of couches, with cushions and legs in relief. Like the tombs of Phrygia, many of the doors are fictitious, the real openings being below: like these tombs also, there are instances of perpendicular chimney-like shafts, leading into the chambers. At Bieda, the sepulchres are arranged in terraces, communicating by flights of steps; here detached masses of rock are carved in imitation of houses, with sloping roofs and overhanging eaves. At Norchia, are two very singular temple-like façades; columns have been attached, but they are now broken away; these façades have a frieze with a triglyph-like ornament; the cornice of the pediment terminates on each side, in a volute, within which is a gorgon's head, a favourite sepulchral device; figures are carved in bold relief in the tympanum.

It is singular that in a country like Italy, abounding in artists and learned societies, and traversed year after year by tourists of all nations, such relics of antiquity as these cemeteries could have remained undiscovered until the last half-century, though within a few miles of the high road between Florence and Rome. The necropolis of Sovana, no less rich in excavated tombs than those of Castel d' Asso, and Norchia, was first explored by Mr. Ainsley in 1843. Most of the sepulchres bear inscriptions in the mysterious Etruscan language.



Tumulus at Tarquinii, restored.

In other parts of Etruria, the form of sepulchre was that of a cone or tumulus; these were formed by a low circular wall of masonry, in which were the entrance doors, and surmounted by a cone of earth; the apex was occupied by a figure of a sphinx, and similar figures were ranged along the coping of the wall. The tumulus inclosed several tombs, that of the lucumo, or chief person, being in the central and highest part ofthe cone. This form of sepulchre prevailed at Tarquinii: the necropolis of this city occupied an extent of sixteen miles; 2000 tombs have already been opened, and a rich store of vases, bronze, and gold work, and other curiosities brought to light. In the palmy days of Etruria, the corpse was laid in a carved sarcophagus. Numa Pompilius left directions, "that his body should not be burnt, but should be laid in a stone coffin, after the manner of the Etruscans." In still more ancient times it was the custom to lay the dead on a bier, or funeral bed, clad in armour or robes of state.

Mrs. Hamilton Gray, the accomplished authoress of the 'Tour to the Sepulchres of Etruria,' gives the following account of the opening of a Tarquinian tomb:—"In the year 1826, Carlo Avolto, of Corneto, had a most unexpected glimpse of a Tarquinian lucumo. On removing a few stones from the upper part of a sepulchre, he looked through the aperture to discover the contents, and behold, extended in state, before him lay one of the mighty men of old. He saw him crowned with gold, and clothed in armour; his shield, spear, and arrows were by his side, and the warrior's sleep seemed rather to be of yesterday, than to have endured well nigh thirty centuries. But a sudden change came over the scene, and startled Avolta from his astonished contemplation: a slight tremor, like that of sand in an hour-glass, seemed to agitate the figure, and in a few minutes it vanished into air, and disappeared. When he entered the tomb, the golden crown, some fragments of arms, and a few handsful of dust, were all that marked the last resting-place of this Tarquinian chief."

According to Mr. Dennis, the painted Etruscan tombs only average about one in five hundred; a sufficient number, however, exist to enable us to trace the progress of Etruscan art, from the stiff and ludicrously disproportionate figures of the early ages, to the exquisite grace and sentiment of the most cultivated period. It is a question much discussed, whether the Etruscans copied their art

from the Greeks, or whether the Greeks were indebted to the Etruscans. Notwithstanding the tradition of Demaratus of Corinth settling at Tarquinii, with the artists Eucheir and Eugrammus, "cunning hand," and "cunning carver," I am inclined to believe that the love of the arts sprang up amongst each people independently, and, perhaps, simultaneously; and that owing to mutual intercourse, mutual improvement may have taken place. The early, or archaic style, both in Etruria and in Greece, was stiff and rude; but as the arts progressed, the Greek and Etruscan schools (if I may so express it) became more distinct. The Etruscans never attained to that perfection in drawing and matchless grandeur of design, that renders Greek art pre-eminent even at the present day; but they delineated the scenes and feelings they wished to perpetuate, with a grace and tenderness that has only been surpassed by the after-dwellers in the same land—the mediæval artists of Italy.

Etruscan Early Style, from Antique Vase.

Etruscan Later Style, from Tomb at Tarquinii.

The paintings in the sepulchres of Etruria do not represent the avocations of daily life, as in those of Egypt, but generally funeral feasts or processions; or frequently allegorical subjects, such as the contest between the good and evil spirits for the soul of the departed, or the last sad parting scene, where the inexorable angel of death, with uplifted hammer, is about to strike his destined victim, while weeping friends gather round. The Etruscans appear to have used colours conventionally, giving their paintings a somewhat absurd effect to our uninitiated eyes; thus, the countenances of the male figures glow with a brilliant red, emblematical of their state of beatitude, and the horses rejoice in black hoofs and blue tails. They, however, made use of the secondary colours, such as greys and violets—so rarely found in ancient art, and their ornamental borders show an advance of taste beyond the stiff and crude patterns of the Egyptians. The Etruscans never excelled in sculpture, probably owing to the want of material, (Limo, or Carrara marble, not being then quarried); but in moulding in terra-cotta, which Varro calls the mother of statuary, or in metal work, they were unrivalled. We are assured that Etruscan vases of gilt bronze were considered by the Greeks as amongst the most valuable household goods; and the statue of Minerva, the masterpiece of Phidias, was adorned with Tyrrhenian (or Etruscan) sandals.

I have mentioned before that the Etruscan government was founded on an exclusive aristocracy; thus the population was divided into the two classes of nobles and serfs; the latter were employed by their masters in task-work, who were thus enabled to carry out those vast undertakings for which they were so celebrated. We must, however, do the Etruscan lucumones justice, for their clients were not burdened to produce monuments to the selfishness and vain glory of their lords, as in the East, but were occupied in great public works, for the benefit of the whole community. Etruscan roads extended from one end of Italy to the other, and even across the Alps; and noble arches of stone were thrown over rivers and ravines; the Ponte Labadia, and others, still show foundations of Etruscan masonry beneath the Roman repairs. According to Dr. Meyer, the roads were constructed in the following manner:—the ground was dug to the depth of two feet, and beams of charred wood laid as a foundation; upon this was placed silaria, or a composition of earth and stone ground to paste, and then a layer of basalt over all. Another method was to lay terra-cotta or broken stones first, and then to pave with hewn stones upon this foundation. But the most magnificent achievements of the Etruscans were the extensive tunnels and draining, by which the country of Italy was changed from an unhealthy swamp to the garden of Europe. Formerly the heights only were habitable, on account of the malaria: the site of Florence was a lake; and the beautiful Val d'Arno nothing but an unwholesome marsh. A tunnel was cut through Monte Gonfalina, which drained the valley, and enabled it to be brought into cultivation. Tunnels were also excavated at Fiesole, from lakes Meoni and Galano, and other places too numerous to mention: even at the present day, Etruscan emissarii are constantly being discovered. The learned Niebuhr himself first examined the subterranean conduits at Fiesole, in 1820. They also deepened the channels of the rivers, and straightened their course. Land was gained by draining off lakes that had formed in the craters of extinct volcanoes; several such craters exist about Perugia, and though the tunnels have never been cleared out, they still continue to act.

In speaking of the foundation and building of Rome, we have Etruria still under consideration, as far as the arts are concerned; for, however much historians may differ as to the extent of Etruscan political influence at Rome (Müller believing Rome under the Tarquins to have been an integral part of Etruria, and Dr. Arnold supposing the Tarquins to have been independent kings, though of Etruscan lineage), all agree that Rome looked to Etruria for her architects and artists: nor must this Etruscan influence be forgotten, as subsequently it gave the architecture of the Romans its distinctive character from that of the Greeks. This is not the place in which to repeat the well-known legends of Romulus, Numa Pompilius, and the other early kings of Rome, but they cannot be passed by without a regret that so little is known with any certainty about the first few centuries of the once mistress of the world, and that the writings of Numa Pompilius, the thirty books of the Emperor Claudius on the Etruscans, and other works which might have revealed so much, should be lost to the world.

The hills of Rome are low, but steep and rocky; small villages were already scattered over them, and a colony was established on the Palatine when Romulus and Remus arrived to take possession with their shepherd band. They proceeded to mark out the first boundary of the future Rome, about the year 753, B.C. Romulus marked out the pomœrium round the Palatine, according to the Etruscan ceremonial; and it was for contemptuously leaping over the sacred furrow that Remus lost his life. The pomœrium was a space left both within and without the walls of Etruscan cities;—the word is variously derived from *post murem*, or *pone muros*, or *proximum muro*: it was never built upon, nor applied to agricultural purposes, but was used by the augurs in taking the city auspices. The pomœrium was carried further out as the city was enlarged, and its boundaries marked by cippi, or termini. When the foundation of a new city was to be laid, a favourable day was appointed by the augurs for marking out the boundary; a line was first drawn with white earth or sand; a copper share was then fixed to a plough, to which were yoked a bullock and a heifer; the plough was guided along the line by the chief or king. Both the animals were to be white, to denote the simplicity and purity in which the citizens ought to live. The bullock was placed on the outside, or next the country, to show that it depended upon the men to cultivate the land and guard the public safety, by watching over what might take place without the walls; the heifer was turned towards the city, significant of the household and domestic cares devolving on the female. The plough was guided so that all the clods should fall inwards, another person following to see that none remained outside: this was to teach the people to gather together within the city all that could contribute to its increase and prosperity, and to leave nothing beyond its limits that could be hurtful to it, or advantageous to its enemies. The sacred plough was lifted over the place where the gates were to be, otherwise no dead body or unclean thing might have been carried out. The new city was then placed under the protection of some

divinity, by a secret name, that its enemies might not be able to divert the divine favour: it is said the secret name of Rome was Valentia. At the founding of Rome a subterranean vault was constructed under the place called the Comitium; this vault was filled with the firstlings of all the natural productions used as food, and with earth brought from the native place of each of the mixed people that were to form the future population of Rome. The vault was called Mundus, and was believed to be the entrance-gate to the world of spirits; the door was opened three days in the course of the year, to allow the souls of the dead to enter. Lucerum, on the Cœlian, supposed to have been an Etruscan settlement, was first united with the Palatine; then the hill of the Sabines, in early times called the Agonian, but afterwards the Quirinal, of which the Capitoline was the citadel. After the rape of the Sabines and its consequences, when these two cities of Rome and Quirinum had united on equal terms, the temple of the Double Janus was built on the road between the two hills, with a door facing each city; these doors were open during war, that succour might pass between the allies, but closed in time of peace, to denote their being distinct though united. By degrees, as union was cemented, and friendship fostered by intermarriage and a common religion, the two cities agreed to have but one king, and one senate, and thus became incorporated. Ancus Martius built the first bridge over the Tiber, and a fort on the Janiculum. The bridge was a kind of wooden draw-bridge, the Tiber being the great division between Etruria and the kingdoms of the south: it was not until several centuries after the establishment of the Commonwealth, when the Roman dominion had become enlarged and consolidated, that a permanent stone bridge was built. The prison, the most ancient building now existing in Rome, is also said to be of the time of Ancus Martius. The splendour of Rome began with Tarquinius Priscus; under this king the city, with its seven districts, was surrounded by a stone wall. The wall was built along the outside edge of the Quirinal, Capitoline, Aventine, and Cœlian hills; from the Cœlian it extended to the Esquiline, where a high rampart, strengthened by towers, was raised from the Esquiline to the northern side of the Quirinal. This rampart was 50 feet in width, and above 60 feet in height; the moat out of which the puzzolano was dug with which the wall was constructed, was 100 feet in breadth, and 50 feet in depth: the rampart was faced with flag-stones on the side next the moat. Much of the space within the wall at that time (considerably more than the usual pomœrium) was entirely uninhabited and uncultivated, and might almost appear to have been inclosed in a prophetic spirit, foreshadowing the increase and glory of Rome. The Viminal, when thus inclosed, was overgrown with osier thickets, and the Esquiline took its name from the oak-woods with which it was covered. The herdsmen, with their cattle, took refuge within the walls in time of war. These fortifications would seem to imply Etruscan domination; for as Rome was situated at the southern verge of their kingdom, they would naturally make it a stronghold against the southern states; but would scarcely have sent Etruscan artificers to an infant city to fortify and adorn it, when it might turn its strength against them as soon as completed—an event which occurred on the expulsion of the Tarquins. That Rome, during the first few centuries, was in itself insignificant, is evident from the fact, that while the Greeks held constant intercourse with Etruria, Rome was scarcely known to them before the time of Alexander the Great. The first mention of the name is found in the writings of Theopompus, who lived in the time of Philip of Macedon; and Heraclides of Pontus, a disciple of Aristotle, mistakes Rome for a Greek maritime city, and mentions it as being attacked by a fleet of Hyperboreans, instead of by the Gauls.

It is doubtful whether the erection of the Capitoline temple of Jupiter is to be ascribed to the first or second Tarquin. It was built after the Etruscan manner, though on a more splendid scale than usual; for the portico which faced the Palatine had a triple row of columns, while a double peristyle inclosed the sides: the foundations of the ancient structure are still in existence. A chariot of terra-cotta was ordered to be prepared at Veii, to ornament the pediment of the Capitoline temple. When the chariot was in the furnace, the clay was observed, instead of contracting as usual, to expand, so that the workmen were obliged to take down the furnace to get it out. On consulting the augurs respecting this miracle, it was decided that it was an omen of increased diminion to whichever city should obtain possession of the chariot. The Veiientes, upon hearing this, determined to keep it themselves, making an excuse that the Romans had forfeited their right to it by the expulsion of the Tarquins, by whom it had been ordered. Soon after, a chariot race took place at Veii, when, to the consternation of the people, the horse of the winner took fright without any apparent cause, dashed along as far as Rome, to the foot of the Capitoline-hill, where the charioteer was thrown out and killed on the spot. The people of Veii imagined this catastrophe to be a warning from the gods, and immediately gave up the contested chariot to the Romans, who placed it in triumph on the pediment of their temple.

The most celebrated of the Etruscan works in Rome, is the great Cloaca Maxima, which pours its river-like water into the Tiber, after draining the Velabrum and the valley of the Circus, previously an uninhabitable swamp. This great cloaca is composed of three semicircular arches, one within the other; the span of the innermost being 14 feet, and formed of hewn blocks of peperino, fitted without cement. Another great drain running into it was only discovered in 1742. In short, it is affirmed by some authors that Rome was subterraneously navigable. Public officers were appointed to keep the sewers in repair, called "Curatores cloacarum Urbis." On the land reclaimed by means of these drains, Tarquinius granted space for a forum, round which porticoes were erected. He also allotted another part of the redeemed ground for a circus. The building materials of the Romans at this time, was confined to the peperino of the quarries of Alba and Gabii, the tufa of the Campagna, and the porous travatine of the Anio—materials wholly unsuited to decorative architecture.

In the year 509, B.C., Tarquinius Superbus was driven from Rome, and the Commonwealth declared. From this time until the commencement of the Empire, the people were occupied with unceasing wars, and no great architectural works were executed. Soon after the banishment of Tarquinius and his family, Tarquinii, the capital of Etruria, was destroyed. After this the Etruscans gradually lost power and influence, though they preserved their peculiar religious rites till the Christian era. One by one, the great Etruscan cities fell, till the country passed under the dominion of Rome, in the time of Scylla, 90 B.C.

From the time of its subjugation to the last half century, Etruria was almost a forgotten name. Within the last few years much interest has been excited, and many valuable works written; and there is little doubt that future research will throw yet more light upon the arts and history of the once refined and powerful Etruscans.

In my next lecture, I shall begin the history of Greek architecture; commencing with an inquiry into its origin, and the causes of its pre-eminence.

LIST OF AUTHORITIES.

Vitravius.—History of Rome, Niebuhr.—History of Rome, Dr. Arnold.—Monumenti Etruschi, Inghirama.—Tour to the Sepulchres of Etruria, Mrs. H. Gray.—History of Etruria, Mrs. H. Gray.—L'Italia avanti il dominio dei Romani, Micali.—Monumenti inediti, Micali.—Descrizione di Cere Antica, Canina.—Cities and Sepulchres of Etruria G. Dennis.—Hypogei, Byres.

ON THE EXPLOSION OF STEAM-ENGINE BOILERS.

Of late years, and more particularly during the last few months, steam-engine boiler explosions, both in this country and in the United States of America, have been of very frequent recurrence.

The awful sacrifice of human life, and great destruction of property usually attendant on them, invest these matters with grave interest.

In the United States, high-pressure steam is commonly employed; essentially so in the steamboats which navigate the Delaware, the Hudson, and the Mississippi. In the United Kingdom, although high-pressure steam-engines *are* used, yet the employment of them may be considered as the exception, not the rule.

Anomalous as it may seem, it is nevertheless true, that explosions of the kind, in this kingdom, more frequently take place with boilers worked either at low, or at moderate rates of pressure, than with those worked at high. We wish particularly to impress this knowledge on the public mind. It is essential to the interests of the community that it should be so. A want of that knowledge, combined with the erroneous opinions which generally prevail on the cause of steam-boiler explosions, and which attribute such accidents, almost universally, to great intensities of pressure of steam, or the liberation of the gases, have, we are induced to believe, been the cause of many such catastrophes. When, therefore, we reflect how important it is for the proprietor of a steam-engine, as well for his own pecuniary interests as the personal safety of those who are employed by him, to be acquainted with every

minute particular of matters of this nature, we are led to explain, what, in our opinion, is one primary cause of such explosions.

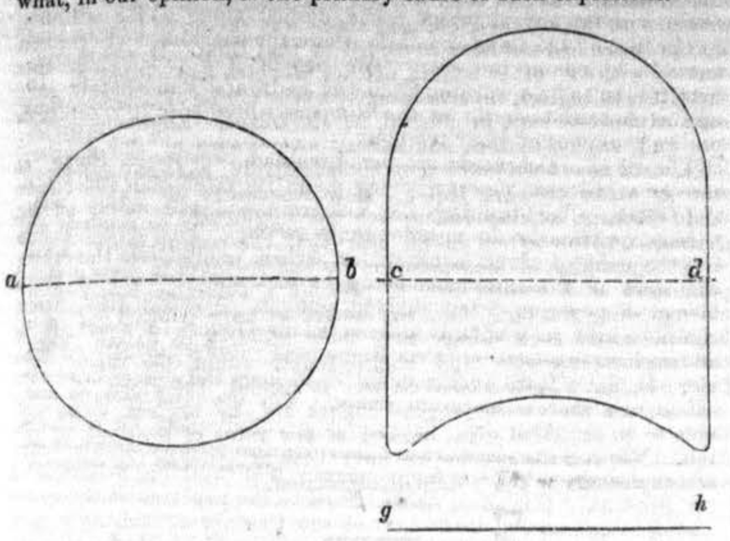


Fig. 2. Fig. 1.

In the preceding woodcuts, fig. 1, represents a vertical section, and fig. 2, a plan of the underneath part of a circular-shaped boiler, concave at the bottom, and hemispherical or domed over at the top; not uncommon in the mining districts of the kingdom. Boilers of this kind, from having been extensively adopted by the eminent engineer, are not unfrequently called, the "*Smeaton-boiler*." By other persons, the "*egg-boiler*," from its appearance, when rising above the brickwork, assimilating to that of an egg in its cup.

It has fallen to our lot to witness, during our professional practice, the destructive effects of explosion, as produced by two boilers of this peculiar construction: one in Lancashire, the other in Staffordshire. In both instances, the boilers, though of great weight, were lifted from their seats, and blown to almost incredible distances. Yet, the boilers were employed ordinarily in generating low-pressure steam; and, so far as could be ascertained, there was no reason to doubt that, at the time, either of them was acting otherwise than in the usual manner. Numerous opinions, entirely of a speculative character, were advanced as to the causes of these explosions. Most of them hinged, as is usual in such cases, either on the supposition that the safety-valve was defective, which allowed of an undue augmentation of steam in the boiler, until it attained to a pressure that could not be resisted; or, to the non-effective working of the hot-water pump, which, by not supplying the boiler with water to compensate for that vapourised, allowed the metal of the boiler to become so heated by the action of the fire, as eventually to absorb the oxygen from a portion of the water, and thereby liberate its other constituent, *the hydrogen*,—whereby, in the opinions of such persons, explosions do take place. We, from our own examinations, entertained very different thoughts at the time, although we had not occasion publicly to avow them. Since those periods, the personal inspection of numerous boilers have confirmed the impressions we then entertained.

We shall now endeavour to elucidate, by familiar exposition, the causes of such explosions; and we do so the more willingly, as we are in the hope that much good may be educed, by eliciting the attention of engine proprietors and engine-tenters to the matter. We must state, however, in the first place, that as we have not got by us, convenient for reference, the dimensions of the two boilers, to whose explosions we have referred, we shall, for the argument, take supposititious dimensions.

Suppose the diameter of the circular part of each boiler, at *a*, *b*, or *c*, *d*, to have been 12 feet, and that, for sake of simplification, the curved top and bottom parts of the boiler, though convex and concave, be considered to have been flat,—each presenting the same diameter of 12 feet; under such circumstances, the area of the top and bottom plates, respectively, would have been 16,286 inches. If, therefore, the presure of the steam within the boiler ranged no higher than 12 lb. beyond the atmosphere, the total amount of pressure on the top and bottom plates would not have been less than 195,432 lb., or about $87\frac{1}{4}$ tons each.

Now, if we examine attentively the nature of this pressure, or force, we shall perceive that, so long as the boiler remains sound, or is in good condition, this enormous amount of power acts equally, *and internally*, both against the bottom of the boiler with a tendency to force it the more firmly on its seating of brick-work and against the top of the boiler with an inverse tendency to project it into the air on the principle of the sky-rocket. Both forces being equal, and acting in opposite directions, balance one another. Hence, so long as the boiler remains sound, these conditions are undisturbed, and the action of the force is equivalent to that of statical equilibrium. The boiler, therefore, has no tendency to ascend or descend, by virtue of that pressure; but is retained on its seat by the weight of the metal of which it is composed, and the weight of the water within it.

Suppose, however, on the other hand, that from long usage, and consequent weakening of the boiler by the action of the fire upon it, a rent, or considerable fracture of the metal, takes place below, so as to allow of a sudden and comparatively large escape of heated water into the flue, or space *g*, *h*, and on and against the red-hot brick-work. The consequences then become frightful. The pressure on the top and bottom of the boiler, *internally*, still balance one another, minus the less amount of pressure on the bottom, caused by removal of that portion of the metal displaced by the fracture. But underneath the boiler, between it and the brick-work, the destructive effect of the pressure—caused by instantaneous evolutions of large bodies of steam from the heated water and heated brick-work—becomes alarmingly great. It is of itself amply sufficient, without extraneous aid, to account for all those devastating and painful casualties we are accustomed to witness at such times.

We repeat that, just before, and immediately subsequent to the fracture, the pressures in the interior of the boiler are equal, minus the less amount of pressure on the bottom, subducted by the opening made by the rent. But beneath the boiler, the pressure acts equally against the brick-work of the flue, *g*, *h*, and the under-side of the bottom part of the boiler; and as this latter is unconnected with its seating of brick-work excepting by its weight, which in a boiler of that construction, does not, with its complement of water, often exceed twenty tons, the projection of the boiler into the atmosphere is the inevitable result.

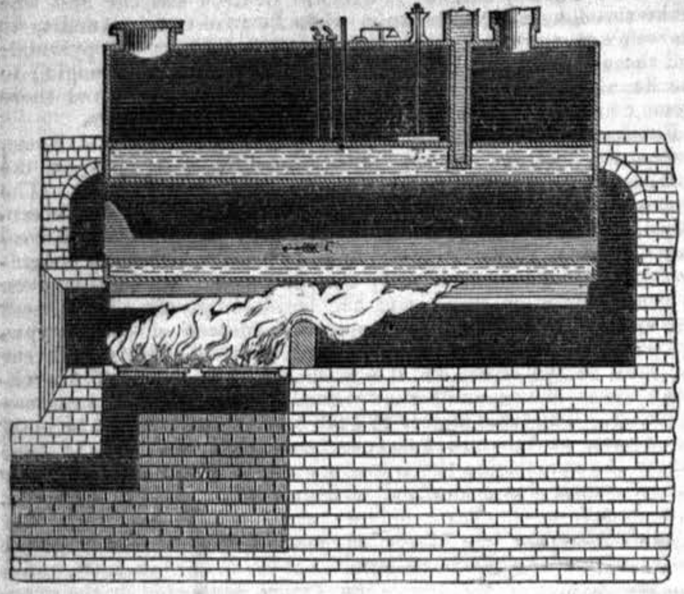
It is not possible to determine what the amount of that projectile force may be. For, when the fracture takes place, and the water, by escape, occupies a greater space, the pressure of the steam is most probably diminished in the interior of the boiler, although acting with equal intensity of force *as regards that pressure*, both against the top and bottom of the boiler internally. But beneath the boiler the pressure is augmented to an enormous extent, partly by large bodies of the heated water—already at the temperature 245°—flashing, when liberated, instantaneously into steam; and partly by other quantities of such water being projected against the red-hot brickwork of the flue, and on the large mass of ignited coal on the fire-grate—and, by suddenly absorbing from such sources other and large quantities of caloric, being as instantaneously flashed into steam. It should also be borne in mind, that the additional quantities of steam thus generated exert no force whatever inside the boiler, or comparatively none; and that the whole amount of the pressure is directed against the exterior of the boiler, increasing, largely, the projectile power.

Suppose, therefore, that the amount of pressure lost by the escape of the water into a larger space, at the time of the fracture, to be reinstated by the additional quantities of steam thus suddenly evolved (and we think it quite possible), it will be perceived that, in such case, the pressure exerted against the under-side of the boiler by the newly-evolved steam, is $87\frac{1}{4}$ tons; that the resistance to that force is derived only from the weight of the boiler, and the water within it, together amounting, probably, to $17\frac{1}{4}$ tons; and that the projectile force is equal to 70 tons. Hence, the boiler must be blown from its seating, and projected through the air, and the brickwork be scattered in every direction. But even if we admit the force, as exerted by the pressure, to be equal only to one-half of that amount, or 35 tons, still *being derived from an elastic agent*, it is amply sufficient to produce all those devastating effects, which, under such circumstances, we are accustomed to see recorded.

The direction that an exploded boiler may take in its flight most probably is influenced by the position of the fracture. This will be better understood by reference to the subjoined diagram (*see next page*).

In the preceding section let fig. 3 represent a wagon-shaped steam-engine boiler, set in the usual manner, in brickwork. By the arrangement, as thus exhibited, the flame, and heat, and gaseous products of combustion, pass from the fire-grate over the bridge, along the bricked flues beneath the boiler, and at the back of it;

thence through the metallic flue of the boiler, into the bricked flue at the front of the boiler, where the current divides itself, and passes through two brick flues, arranged one on each side of the boiler, into the ordinary damper-flue, whence it passes into the chimney.



By examining the diagram it will be at once obvious that, as the flame and heat flow continuously over the bridge, and through the flues beneath, and at the end of the boiler, the brick-work of those flues must imbibe so much caloric as to become red-hot. Further, that should any fracture or rent of the boiler take place, so as to allow of a portion of the heated water to flow thence, on that red-hot brick-work, enormous volumes of steam must be *instantaneously* generated—capable, by that agency alone, of producing all those disastrous effects to which we have referred. In a wagon-shaped boiler, however, the effects, under the same pressure, will be greater than with the Smeaton or egg-shaped boiler, by consequence of the greater area exposed to the pressure.

It is well-known, naturally, that all power is transmitted in a right line, and that the operation of compound forces is necessary to produce any deviation from it. If, therefore, the steam thus suddenly evolved from the heated water by its coming into contact with the red-hot brick-work of the flue, could, at the same instant of time, be equally diffused under every portion of the bottom only of the boiler, and act on every part of it with equal intensity of pressure, there is not a question that the boiler would be projected vertically into the air. But such range of flight is barely likely to take place. Even if the steam could be equally diffused under every portion of the bottom part of the boiler at the same time, the fire-grate, owing to the interstices between the fire-bars, does not present that firm base for the steam to act against as is presented by the solid mass of brickwork behind the bridge. Therefore, the great probability is, should any such fracture take place, either over the bridge, or on the right-hand side of it, or over the flue, to however small an extent, the boiler will be projected through the air in an oblique direction; and the deviation from the vertical line will be greater or less, accordingly as the fracture takes place nearer to, or farther from, the bridge, towards the chimney. The greater accession of heat, also, that may be imparted to the water by such brick-work, and the action of the pressure on the end of the boiler, at the flue will tend, still further, to the oblique direction we have stated.

The observations we have thus made are of great practical importance. Hitherto, from the awful effects of such explosions, the minds of practical and thinking men have been devoted more to a search after some unexplained cause for increased production of pressure within the boiler, rather than to an elucidation of the simple one we have developed, and by which, in our opinion, most of those catastrophes are produced. High-pressure steam is not indispensably necessary to an explosion. Low-pressure steam is amply commensurate to the end. We have shown this by our remarks on the explosions that took place of the two Smeaton or egg-shaped boilers; and we can confirm or strengthen the statements by adding, that we were present shortly after, and witnessed the effects that had been produced by an explosion of a wagon-shaped boiler. It had been worked, customarily, at from 7 to 9lb. pressure on the square inch, and there was reason to believe that that pressure had not been exceeded at that time. It was in connection with two other boilers, neither of which had exploded. In short, it is to neglect, superinduced by a false notion of security, that such explosions may, in general, be attributed. Engine proprietors and engine-tenters, not having been aware of the danger, have, until now, been indifferent, comparatively, as to any defective state of a low-pressure boiler. How frequently do we see such, while working, leaking badly; but not sufficiently to produce an explosion. How often do we hear that the engine-tenter, even with the sanction of his employer, has had recourse to some paltry patchwork of a contrivance, to prevent a defective boiler from extinguishing the fire. Had the danger we have pointed out been known, would such things have been allowed to exist? Both the engine-proprietor and engine-tenter would, for their own interests, have been averse to it. It cannot, therefore, be too well-known that steam-engine boilers are, by neglect, quite as liable to be exploded when worked at low rates of pressure as at high. Nor can the reasons we have thus assigned as the cause of such explosions be too widely disseminated.

IMPACT OF ELASTIC BEAMS.

On the Impact of Elastic Beams: Abstract of a paper read before the Cambridge Philosophical Society, Dec. 10, 1849. By HOMERSHAM COX, B.A. Jesus College. [From the *Philosophical Magazine.*]

"Among the experiments instituted by the Royal Commission, appointed to inquire respecting the use of iron in railway structures, was a series relating to impact on beams. These experiments were undertaken by Professor Hodgkinson, and were conducted in the following manner. The two ends of the beam were fixed in a horizontal position, and the blow was given against one of its vertical sides, in a horizontal direction. The instrument for giving the blow was a heavy iron ball, hanging down, when at rest, from a point of suspension vertically above the centre of the beam. The ball was raised through different arcs, and after descending by its own gravity struck the beam. The deflection corresponding to different arcs of descent were carefully noted by a graduated scale. The object of the present paper is to show that the results might have been predicted by known theoretical principles with considerable accuracy. The problem is divided into two parts: 1st—to estimate the amount of velocity lost by the ball at the first instant of collision; 2nd—to ascertain the effect of the elastic forces of the beam in destroying the *vis vivâ* which the whole system has immediately after collision.

"In the first part of the investigation a general formula, derived from the combination of D'Alembert's principle and the principle of Vertical Velocities, is given for the motion of any material system subject to impact. The requisite geometrical condition required for the application of this general formula, is obtained by the assumption that immediately after impact, the form of the beam is a gradual and tolerably uniform curve, such as, for example, the elastic curve of equilibrium. In this way it is determined that about one-half the inertia of the beam is effectively applied at the instant of collision to retard the ball.

"The *vis vivâ* of the whole system thus computed, is destroyed by the elastic forces of the beam developed by deflection. These, in the second part of the problem, are assumed to vary as the amount of the central deflection. By the principle of *vis vivâ* a formula is easily obtained, connecting the total deflection with the *vis vivâ* of the system immediately after collision.

"Tables are given, in which the theoretical and experimental results are compared. The correspondence is of the closest and most satisfactory nature. Indeed, the theoretical results generally differ less from the mean of several experiments, than those experiments differ among themselves. Both in the theoretical and experimental inquiries, every possible variation of the elements of the investigation—the relative masses of the beam and ball—the velocity of the latter—the rigidity and dimensions of the former—have been included."

THE MAUSOLEUM OF HADRIAN.

On the Mausoleum of Hadrian, now the Forte St. Angelo, at Rome. By the Rev. Richard Burgess, B.D.—(Paper read at the Royal Institute of British Architects, March 4th.)

It is remarkable how much knowledge of the habits, occupations, and even religion of an ancient people may be gained from the kind of edifices their architects were called to construct. So much so, that, if the pages of history were blotted out, the dumb monuments, which time has spared, would speak to us of the recreations, the morals, the mode of life, and even the mode of death adopted by the ancient Greeks and Romans. In no age has the architect the choice of the kind of buildings he would erect. His business is to give shape and proportion to the edifices which the climate, the habits, the religion or the popular pursuits of a people demanded. The buildings of ancient Rome, which afforded the most ample scope for architectural skill, would not be required, for instance, in our metropolis. The buildings, which gave scope for the architect's skill, the porticoes, theatres, baths, are lost to our time and climate.

It is with special reference to sepulchral monuments that I have introduced these preliminary remarks. These afforded a field for the architect of classic times, which in our day has been entirely transferred to the stonemason. The pyramids in Egypt, the monument of Philopappus at Athens, and the sepulchres of Augustus and Hadrian at Rome, were among the most conspicuous edifices of their respective countries and ages. But where now should we find a tomb in our public cemeteries or grave yards which would require any skill to construct, beyond what might be found in a very moderate artist? I speak not of the monuments of our great men, which the art of sculpture has touched, and which stand under the shelter of a cathedral vault. Speaking, as I intend to do, of sepulchral monuments as buildings, I have yet to ascertain the cause why this class of edifice has been lost to the modern architect. The cause is in the change which Christianity has wrought in the hopes and prospects of what may happen after death. The ancients considered a tomb in a much more important light than we either can or ought to do. So feeble were their expectations of living in their fancied elysium, that they generally looked forward to the honour of a tomb, as the only blessing that awaited them. Hence the anxiety so frequently discovered on monumental inscriptions, which the individual during lifetime had for providing for himself and his family a place of burial free from intrusion. The initials, "H. S. F. V."—*Hoc sibi fecit vivus:* "He made this for himself while he was alive"—we constantly find on ancient tombs. And we cannot wonder, that the wealthy, under these circumstances, should have bestowed so much of their substance in erecting their private monuments, and the warrior and the statesman so much care and toil in gaining this as a public honour.

The ancient Romans erected their splendid tombs by the sides of the public roads, and from the remains still existing along the Via Appia, that road might, without any further indications, be traced for at least four miles from Rome. The sepulchres of the Scipios, the Metelli, and the Servilii are enumerated by Cicero as amongst the tombs which stood without the Porta Capena. And he thinks, that no one, looking on those monuments of the illustrious dead, can esteem the buried inmates unfortunate. This was all the immortality to which the Egyptian Pharoahs, the Athenian sages, or the Roman generals aspired; and therefore the more durable the monument, and the more conspicuous its massive walls, the more the honour, the greater the consolation. Palinurus was soothed by the assurance, which Æneas gave his wandering ghost, that he should have a Cape called after his name, which would be more durable than even a mausoleum.

> Æternumque locus Palinuri nomen habebit
> His dictis curæ emotæ
> gaudet cognomine terra.——Virg. Æn. vi. 382.

The early sepulchres of the Republic at Rome were of that kind called "Hypogæa," that is, chambers underground, with an elevation little more than enough to exhibit the inscription to the passers by. Such were the sepulchres of the Scipios, as it is yet to be seen near the Porta St. Sebastiano. But towards the end of the Republic, when the luxury of marble began to be known, and governors of provinces returned home laden with the spoils of the East, the colossal taste in sepulchral monuments was introduced. The rich Crassus erected a mausoleum for his wife on the Via Appia, built of travertine stone, twenty-four feet thick; and every one who has visited the Campagna at Rome, will be familiar with the striking monument of Cecilia Metella. Forsyth observes, "the general form of the tombs on the Appian Way, is a cylinder or a truncated cone with a cubic base and a convex top. This combination," he says, "conveys the idea of a funeral pyre, and has some tendency to the pyramid, the figure most appropriate to a tomb, as representing the earth heaped on a grave, or the stone piled on a military barrow." Perhaps Crassus was the first who broke through this general rule, when he gave more rotundity to his wife's monument. Caius Cestius went back to the pyramid: and these two monuments, which we may consider as belonging to the Republic, have now stood for nearly 2,000 years, and there seems no reason why they should not stand for 2,000 more.

But I come now to the two great sepulchres of Imperial Rome. Augustus chose for the site of his mausoleum a place in the Campus Martius, between the Via Flaminia and the Tiber. The remains of that monument are now to be seen behind the Palazzo Corea, near the Porto di Ripetta. The ancient walls are so concealed or involved with the surrounding buildings that its magnitude can hardly be estimated by the spectator. Strabo has given us some description of it, and he considered it the object most worthy of notice among the splendid edifices of the Campus Martius. It stood upon a lofty substruction of white stone, near the bank of the river; and it was shaded to the very top by evergreen trees. The summit was crowned by the statue of Augustus in bronze. The trees appear to have been planted on the belts of the stories, as the circumference contracted towards the top. Behind the mausoleum there was a grove laid out in walks, the care of which was committed to a procurator. The tomb was built twenty-seven years before the Christian era, and it is probable that the boy Marcellus was the first of the imperial family interred within its walls.

> quæ, Tiberine, videbis
> Funera, cum, tumulum prætcrlabere recentem!

It was in this tomb that Agrippa and Drusus were buried. And in the nineteenth year of the Christian era, Agrippina, in the midst of weeping crowds of citizens, brought the ashes of Germanicus to be placed within its walls. But the monument, which was designed by the first master of the Roman world to be the silent repository of the ashes of himself and his posterity, has come to an ignoble end. The ruins, which time and Robert Guiscard the Norman, have left, are now consolidated into the platform of an amphitheatre; and in the summer months, several thousands of the Roman people sit round the ample circumference, to witness the horrors of a bull-fight, the feats of horsemanship, and the antics of a vagrant clown. I have mentioned this monument, in many respects similar to that of Hadrian, in order that I may with advantage introduce the subject which has been announced for this evening.

As if it were to show how little any works, however great, are valued, which have not some public object or utility, this colossal monument, which we are about to view, is hardly noticed by the ancient writers. But there is little doubt that the emperor Hadrian himself was the architect of his own tomb: the whole of his life was dedicated to the arts, and he could ill brook a rival in the science on which he thought he excelled. Apollodorus, the great architect of that day, the man of taste, was doomed to view all the designs the emperor sent him, and to choose between praising what he could not admire, or going into exile. Appollodorus ended in the latter alternative, and left the imperial architect to construct his own mausoleum. Dion Cassius tells us, that when Hadrian was buried in the tomb he built on the bank of the Tiber, that of Augustus was full, and no more ashes could be deposited within it. But I apprehend that Hadrian had cast an emulous eye upon the great work of his predecessor, and perhaps chosen the garden of Domitia, nearly opposite, to confront with greater splendour the monument which Strabo had praised; the rich materials he had probably collected in his travels through the empire, and I imagine like those, who built a still larger tower in the plains of Shinar, the vain notion of his mind might be expressed in the same language—"Come let us make us a name." Be this as it may, all that Spartian, the biographer of Hadrian, tells us about this stupendous work is, "*Fecit et sui nominis pontem et sepulchrum juxta Tiberim.*" The bridge here mentioned, is that which Hadrian erected across the Tiber to give an easy access to his tomb, and which he called Pons Elius, after his prenomen. There is a medal extant, which exhibits this bridge with three main arches in the middle, and at each end two of smaller dimensions. Much of the ancient construction of peperine stone still remains in the vaults of the arches, and with the name changed to Ponte S. Angelo, it preserves to this day the appearance of what it was originally. I am fortunate enough to be able to point to some

exquisite drawings of the arabesque ornaments of some of the vaults and ceilings in the modern compartment; these have been kindly furnished to me for the occasion by the obligeance of M. Grüner, the author, honorary and corresponding member of this Institute.

It appears from various inscriptions that have been found and preserved, that this mausoleum received the ashes of all the Antonines; and the body of Commodus, after being dragged through the Tiber, was also buried in it by order of Pertinax. Something was left by Hadrian for his successors to finish, and it probably continued to be the imperial place of burial until the time of Septimus Severus; perhaps we may say to the middle of the third century. Then its history as a sepulchre ends. But, before I proceed to describe to you the original appearance and splendour of this monument of Imperial Rome, let me bring together the few notices which are found of it in ancient writers. Procopius is the first who gives any description of what it was, in his account of an assault made by the Goths outside the Aurelian gate (that is not far from where the Gauls of 1848 very recently made their assault); he thus writes—"The tomb of the Emperor Hadrian is situated outside the Porta Aurelia, about a stone's cast from the bulwarks of the city, it is an object worthy of admiration. It is built of Parian marble, and the blocks fit close to one another without anything between to fasten them; it has four equal sides about a stone's throw in length; it rises above the city walls; on the top are statues of the same kind of marble, admirable figures of men and horses. The men of old time (that is the Romans, probably, in the time of Honorius), joined this monument with the bulwarks of the city by two walls, because it appeared advantageous for the defence of the city; it thus became a part of the fortifications, and had the appearance of a lofty tower covering the entrance of the city." So far we learn that the mausoleum was converted at a very early period (for Procopius saw it in 534 A.D.) into a fortress. Those beautiful statues, however, which the secretary of Belisarius describes, were put to a strange use by the defenders of Rome. Instead of more appropriate missiles and more raw material, these masterpieces of sculpture were torn from their pedestals and hurled upon the besiegers below; and perhaps the breaking of the head of a Goth might cost a whole Venus or a Mars, a head of a Faun, or a foot of Hercules. I do not know what to say of a passage cited by Salmasius from John of Antioch, who lived A.D. 620. "The figure of Hadrian," he says, "stood on the top in a car drawn by four horses, of such colossal dimensions, that a full grown man might pass through one of the horse's eyes." A chronicler of the thirteenth century, commonly called the Anonymous, says that the tomb was faced with marble, and he talks of gilded peacocks and a bull. The same mediæval sight-seer mentions also bronze doors and horses, which he saw about the mausoleum. But the earliest representation or drawing we have of the mole is that now existing on the bronze doors of St. Peter's, made in the days of Pope Eugenius, by Antonio Pollagio, about 1481. In Camucci's sketch, made a century later, some of the cornice is indicated which he must have seen, and which he says was embellished with ox-heads and festoons; and on the frieze there were two inscriptions then to be seen belonging to Commodus and Lucius Verus. Pope Clement VII. and his architect Labacco gave currency to the tradition, that the beautiful columns of Paonazzetto, which stood in St. Paul's Basilica, once adorned the upper stories of this mausoleum. Now with these notices of historians and artists of old time, added to our own observations of its present state, we are to make the description, both external and internal, of this durable monument.

The mausoleum was formed of a square basement, which measured 253 feet on each side, making a perimeter of 1012 feet. The door, or entrance, was in the middle of the south side, facing the passage across the bridge. At the four angles of this solid basement were colossal statues, or trophies; I rather suppose them to have been those horses which are mentioned by the monk of Antioch; in the centre of this massive foundation, which was adorned by festoons and bucrani, rose the round tower, which still, in a great measure, exists and serves as the donjon or keep of the castle. This tower did not diminish towards the top as some have supposed, for Procopius measures the diameter at the top by the same expression of a stone's cast, as he measures it at the bottom; though diminished by all the marble facings in width, it still yields a diameter of 188 feet. The round mass was compacted together of peperine stone and the usual materials employed in solid Roman works; but it was all faced with square blocks of Parian marble. We must accede to the generally received opinion that two magnificent colonnades went round the monument, dividing it into two stories, and that statues stood in the intercolumniations. Those statues were probably *chefs d'œuvre* of art. The famous Barberini Faun, which was found by the pontiff of that name in a ditch of the fort is a specimen; the dancing faun in the Florentine Gallery is another; these had either fallen from their place, or had been used by the troops of Belisarius for overwhelming their assailants. The summit of the edifice, which finished in a dome-shaped roof, was crowned, as some think, by the large bronze pine found in digging the foundations of S. Maria Transpontine, and which is now to be seen in the gardens of the Vatican. But it was more in conformity with the ambition of the Roman emperors to have their statues erected on the summit of their monuments: witness the columns of Trajan and Marcus Aurelius, and the corresponding sepulchre of Augustus. The bronze pine would be a more appropriate ornament for some edifice in the gardens of Domitia, in which the mausoleum was erected. Moreover, we have it stated by one of the ancient writers I have quoted, that there was the statue of Hadrian somewhere about the tomb. I have therefore, in spite of some celebrated antiquarians, taken the liberty to place the statue of Hadrian on the top of his mausoleum. From the intimation we have of the ox-heads and festoons, and the inscriptions on the frieze, I have represented the basement as Doric; the first row of columns above would naturally be Ionic; and if the columns of St. Paul's Basilica were really taken from this tomb, they speak for themselves, and will justify us in exhibiting the upper row in the glory of the Corinthian. Upon these data and surmises, therefore, I have presented to you the mausoleum in its exterior, as I suppose it originally to have been; and we may safely conclude that it remained in all its pristine magnificence until the time of the Emperor Honorius, 402. Let us now go within. The spiral corridor, which leads from the entrance to the sepulchral chamber, was entirely excavated in 1820. Beginning from the original entrance facing the bridge, a lofty arch of travertine stone forms the ingress, and leads into a spacious vestibule. Opposite the position of the door of entrance there is a large niche, which no doubt contained the statue of the emperor; a colossal head, now in the Vatican, and a hand discovered in the excavations, probably belonged to the said statue. In a compartment on the left side of the niche is a fragment of a cinerary vase of marble, with some letters upon it, which was lying there when I examined the interior of this monument in 1829. The spiral corridor, by which we now begin to ascend, is about 11 feet in width and 30 feet in height, built of the finest brickwork; the bricks 6 feet long; but the whole has been coated with precious marbles, as appears from the continual fragments still found, and the traces of them yet sticking to the walls. The ascent is not by steps, but by a gently inclined plane, winding round the monument, and showing specimens of the mosaic flooring still adhering to their original places. This wonderful passage was lighted from above by those openings called in Italian *abbaini;* they are cut through the massive covering in pyramidal forms. The light cannot enter by them now on account of the modern works of the forte, which lie over them; and hence this corridor can only be seen by means of torches at present. Pursuing this circular passage we ascend until we arrive where the modern staircase and the light of day meet us, and turning by an arch we come upon the sepulchral chamber. It occupies a space of about 25 feet square, and is lighted by a window at each side, which exhibit at the same time the immense thickness of the walls. Beneath the modern steps are found some cells with lateral niches; in the one on the left of the staircase the French consuls were imprisoned in the great revolution. The Sarcophagus of black and white granite, now in the Museo Pio Clementino, together with the busts of Hadrian, very probably once occupied this chamber. We must not, however, omit to mention that the large basin of porphyry, which serves for the baptismal font in St. Peter's, and the porphyry urn which was taken from the tomb of Pope Innocent II., and several objects of equal value, all came out of the mausoleum. So that if we consider its marble-lined walls, both inside and out, the mosaics of the floors, the beautiful columns which encircled its peristyles, the exquisitely finished statues which adorned the upper stories, the bronze figures which ornamented the basement and surmounted the dome, the alabaster urns and sarcophagi of precious marbles which this treasure house once concealed, it would be difficult to over-rate the magnificence and cost of this gorgeous monument, or to exaggerate the folly of the man who reared it for such a purpose. But the imperial architect little dreamed the purpose to which posterity would put his proud sepulchre, nor to what strange vicissitudes he should be indebted for the perpetuating of his name and the celebrity of his grave.

The history of this monument does, in fact, become a history of Rome itself; and, perhaps, before I proceed to speak of it under the modern appellation of Forte St. Angelo, you may be interested in hearing the vicissitudes through which it has passed. From the time that it was joined to the city walls, A.D. 423, it may be considered no longer as a tomb but as a fortress; and, after being frequently taken by the Goths, and retaken by the soldiers of Justinius it was left in the hands of Narses the Eunuch, in 552, and afterwards transmitted to the Exarchs, who succeeded to power in Italy under the Greek emperors.

In the year 908 this citadel, for so I may now call it, is found in the possession of Albert surnamed the Rich, one of the Counts of Etruria. This prince was admitted to a share of the fortress, by a Roman lady, Theodora, more illustrious for her extraction and power than for her chastity. Her daughter Marozia, more beautiful than her mother, but not more modest, kept the citadel as a place of security for her guilt, and at length she celebrated her nuptials in it with Hugo, called King of Italy, and she gave him up the whole for a dowry. It passed through several members of this family, in succession, until it reached Pope John XII., and then it was for the first time possessed by the Bishops of Rome, A.D. 956. They were masters of it for about twenty-seven years, until it was seized by Crescentius, upon the pretext of defending his consulship. He made entrenchments and outworks to it, in order to defend himself against the Emperor Otho III., who came to espouse the cause of the pope; and after a protracted quarrel of eleven years, it was finally recovered for Gregory V. It continued for a long time after to be called the Tower or Castrum of Crescentius.

During the succeeding ages, and in the time of the troubles which drove the popes to Avignon, and comprising the career of Rienzi, last of the Romans, the fortress held a conspicuous place in history. But, on the return of the popes to Rome, 1376, it fell into the hands of the French cardinals. Through those dark ages it was suffered to fall into decay, until Boniface IX. renewed the fortifications, after the designs of Nicollo de Pietro Aretino. After this it was taken by Ladislaus, king of Naples, but was again restored to Pope Martin V., 1431. But the first important additions of modern times were made by the famous or infamous Borgia Alexander VI; he raised the round tower higher, and erected a bulwark of travertine stone between it and the bridge, almost as we see it in the present day. He also constructed the covered gallery, which communicates with the Vatican, about 3,000 feet in length. The arches under the gallery were made by Pius IV., and it was roofed by Urban VIII. Borgia just finished his work in time for his own personal security. On new year's day, 1495, the king of France (Charles VIII.) with his army, entered Rome by the Porta del Popolo, while Ferdinand king of Naples left it by the Porta St. Sebastiano. The pope, says Guicciardini, "*pieno d' incredible timore e ansietà*," took refuge in the Forte St. Angelo, accompanied by Cardinals Orsini aud Caraffa. Alexander VI. refused to give up the forte to the French, in 1495, but the Pope Borgia sent four cardinals to treat with the French monarch, and succeeded in effecting a brotherly alliance. The pope of 1848 sent three cardinals to treat with a French general, and as it appears with equal success, for the Forte St. Angelo remains in the hands of the pope. The similarity which exists between those transactions, separated by a space of four centuries and a half, is most striking.

Pius IV. was the next pope whose works are worthy of noticef they were not confined to the fortress, but he enclosed the whole o the Vatican and brought his walls down to the Tiber, at the Porta St. Spirito, enclosing the old walls of the Leonine city. Finally, Urban VIII., 1644, completed the walls on the Trastevere, as we now see them, by drawing the line from the walls of Pius IV., and along the top of the Janiculum, and bringing them down to the river at the Porta Portese. The gate of St. Pancrazio and the bastions on each side, rendered so celebrated by the siege of 1849, were all the work of Pope Barberini Urban VIII., and as if anticipating a visit from the old friends of Italy, he appears to have made them much stronger than General Oudinot expected. It was this papal engineer who stripped the Pantheon of its bronze to melt down into cannons for defending the improved fortress of St. Angelo. I have purposely omitted all allusion to the assault of Rome by the Connetable Bourbon, and the bombardment of the Forte St. Angelo, with all the adventures of Benvenuto Cellini in 1527, and when Clement VII. (Medici) took refuge in the fortress.

But having seen this fortress become the occasional residence of popes and cardinals since the revival of the arts, we shall naturally conclude that those dignified persons, who have no antipathy to luxury out of Lent, would not be lodged in rude sepulchral chambers nor shut themselves up within walls of peperine stone or naked brickwork. It will be some refreshment to your eyes, after I have so long wearied your ear, to turn from the heavy walls of a fortification to the decorations of the habitable rooms within, as drawn by the able pencil of M. Grüner. In a saloon in front, which communicates with the balcony facing the bridge, you have some pictures of Pierino Buonaccorsi, called Del Paga, a scholar of Raffaelle; and in the balcony opposite are to be seen some of the designs of Girolamo Siccendante da Sermoneta. But these are nothing compared with the beautiful arabesques which adorn the ceilings of some of the other rooms. I shall not attempt any description of those, because we are favoured this evening with the loan of those exquisite drawings to which I have already alluded. You will remark, as they are passed round the table, the ceiling from which Cardinal Caraffa was, I will not say hung, but suspended; the hook, I believe, still remains in the rosette as a memorial of the deed.

It does not appear in examining the specimen presented to us this evening, that the popes were partial to sacred subjects, or that they thought to reform their state prisoners by representations of heavenly things. Nymphs, Satyrs, Venuses, and Cupids go round together in the mystic dance, and if Christian theology was supposed to have its place at the St. Peter's end of the Borgia corridor, heathen mythology might be very properly imprisoned in the fortress at Rome. I leave you to exercise your own skill upon the mythology, which is couched under griffins bestrode by Cupids, and Mars admitted into the dressing room of Venus. But I particularly propose to your admiration the paintings in a corridor of the Forte St. Angelo, that is in the modern part, by Giulio Romano, as they are rendered by the masterly hand of M. Grüner.

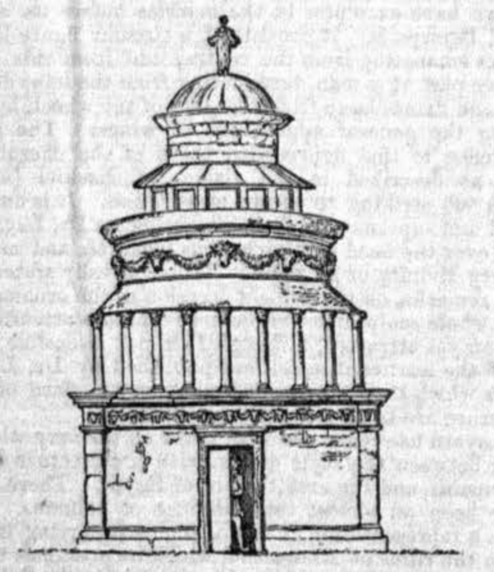
This state prison has always been guarded with great jealousy, and few have ever been known to tell its secrets. Even the artist whose object is known, is admitted with caution; and the antiquary, when he attempts to span and measure, is considered an engineer in disguise. This rigour has been still greater since the recent revolution, and the *entrée* has been next to impossible. The persevering friends of Dr. Achilli, however, did obtain admission, but they do not appear to have seen either Nymphs or Cupids. This is a description which MM. Meymeer and Tonna give of their visit to the interior of the forte on Sunday, 25th November, 1849: "We first crossed a drawbridge, spanning the first or outer ditch, which encircles the bastioned enciente. We walked quite round this; on each of the four bastions a gun is mounted, bearing the pontifical arms: from the height of this wall (which commands to the south and west a view of Rome, and of the Trastevere, and to the north and east the Campagna), we looked with much interest on the prisoners, all dressed in military clothing, who were walking in the deep and damp ditch, which separates the enciente from the immense tower. The base of this latter is of ancient construction. We then crossed another drawbridge which spans this (the second) ditch, and we found ourselves at the entrance of a staircase or sloping path, which crosses in a straight line the whole width of the tower. It was dimly lighted and intersected in four places as we ascended, by traps and drawbridges, each of which would afford successive positions of defence against a party forcing its way from without. On reaching the top we turned to the left, and arrived at an iron gate guarded by French soldiers. They, seeing the unconcerned manner in which we walked up, concluded that we had a pass, unlocked the gate, and admitted us to a platform or court, locking the gate and removing the key after we had passed. Above this court, again, rise the upper buildings of the castle, in which the more important political prisoners are kept, and amongst them our friend. Further than this we could not go. Again the ponderous grating was unlocked, and we retraced our steps down the long and gloomy staircase, and finding that the commandant had not arrived, we left the fortress with a depression of spirit which we could not shake off for the rest of the day. In many parts of the castle we saw inscribed on the walls the name of Alexander VI., the infamous Borgia, and particularly an immense inscription over the gateway of the tower"—

"Alexander VI., Pont. Max. Restoravit, Anno. Sal. 1495."

Such is the most recent intelligence I can give you of the present internal aspect of this remarkable monument, but the prisoner alluded to in the above description having recently escaped, is at this time in London. I should be afraid to trust myself with a beginning of reflections upon the subject I have now finished, for I should be sure in that case to end with a sermon. I will only remark, that however our curiosity may be excited by the stu-

pendous works of antiquity, and however our taste may be gratified by the enchanting powers of art, nothing really interests, either in history or description, but that which was founded for the benefit of mankind, and carried on through ages by the virtue of benevolence. Time is said by our poet to be a beautifier of the dead; but he has not traced a line of loveliness upon the ashes of the selfish emperor, who reared this tomb for his own vanity. Time is said to be the adorner of the ruin; but time has but added deformity to the splendid mausoleum. It is some consolation to know that "glory, built on selfish principles, is shame and guilt;" and it may be a moral lesson not unworthy of the artist and of him who builds for posterity, to learn that whatever in the way of monumental grandeur is not associated with virtuous sentiments, or, as I should say, with morality and religion, will hand down no name to posterity with the reverence and respect, which the architect and the artist, not less than the statesman and philosopher, may lawfully seek to deserve.

The Chairman (Mr. Sydney Smirke, V.P.) said, we have been so often charmed, instructed, and elevated by our reverend friend's eloquence, that I really am at a loss to shape into a new form the expression of our thanks. Our heartiest gratitude is indeed due to him for the great treat he has given us this evening. It is quite clear that Mr. Burgess's treasures of research, as well as of memory, are inexhaustible; for I had hoped that he had not heard of the illustration which the bronze door of St. Peter's offers of this monument. That, however, has not escaped him. I am happy in being able to show a slight memorandum of that *bas relief*, a copy of a hasty sketch which I made when I was in Rome. I do not remember whether the date Mr. Burgess mentioned is perfectly authenticated; I should have thought, from the very barbarous character of this relief, that it was of an earlier date. I dare say, however that he is right; but one would have thought, that in Rome a work upon an imperishable material, on the principal door of the greatest building in Christendom, would have been better drawn.



The very hasty sketch I made will verify nearly all my reverend friend's attempts to realise this remarkable edifice. The great peristyle columns, however, look more like Corinthian than Ionic; and there seems to be an attic over the peristyle, which does not appear in our friend's drawings, apparently enriched with a second band of bull's heads and festoons. The *bas relief* exhibits at the top, not a pine apple but a figure, which looks like a cupid rather than an emperor. It no where indicates the peacocks and bulls to which our reverend friend has alluded.

Mr. Tite seconded the motion for the vote of thanks, which after some observations by Mr. Donaldson, secretary, and Mr. Roberts, fellow, as also by Mr. Lloyd, visitor, was carried by acclamation.

Mr. Burgess returned thanks and promised to communicate a paper next session, if spared another year, upon the Viæ Romanæ, as compared with modern railroads, and with reference to the vastness and magnificence of each.

Stoney Stratford.—A Roman villa has been discovered in the parish of Pauler's Pury, near Stoney Stratford, on the property of the Duke of Grafton, and near the course of the Roman road, Stratford being the Lactodorum of the Romans. Already a fine tesselated pavement has been brought to light.

SCULPTURES AND ARCHITECTURE OF ASSYRIA.

Some Remarks on the Style of Ornamentation prevalent in the Assyrian Sculptures recently discovered by Dr. Layard, *and on some Peculiarities of Assyrian Architecture, as exhibited thereon.* By Sydney Smirke, Esq., V.P.—(Paper read at the Royal Institute of British Architects, March 18th.)

In submitting for the examination of the meeting some casts which I have, through the kindness of the Trustees of the British Museum, been permitted to have made of some small portions of the Assyrian sculpture recently deposited in the British Museum, I beg to detain you, for a few minutes only, with some remarks upon the style of ornamentation which appears to prevail in these very curious works of ancient art.

The love of ornament which distinguishes all eastern nations at the present day seems to have equally prevailed among the ancient people of whom representations are now, for the first time, brought before us in these interesting remains. Very few female figures occur, but scarcely a male figure is represented, whether priest or warrior, without large ear-rings, and most of them have necklaces, bracelets, and armlets. It is to be remarked, however, that not a single case occurs, amidst all this display of personal jewellery, of a finger-ring; the entire absence of this ornament in sculpture, wherein details of this nature are so elaborately and carefully attended to, leads to the unavoidable conclusion that the finger-ring was an ornament unknown to the Assyrians. I am not about to digress into any question of the antiquity of finger-rings, an enquiry for which I am not competent and which would be here inappropriate I will only take occasion to say, that much of learned disquisition as there has been on this subject, the question remains to be answered. I think there has been much confusion produced by the vague use of the word *ring*, and the too ready assumption that when rings are named, *finger*-rings are intended. Signet-rings may have been, and were, worn suspended from the neck, or attached to a chain. There are in the Book of Esther, and in Jeremiah, very clear allusions to finger-rings, but the earliest classical authority that I am at present aware of (and for this I am indebted to my friend, Mr. Birch), is Pausanias, who says that he saw on the walls of a temple at Delphi a painting by Polygnotus of Phocis, represented with a ring on his left hand. Polygnotus flourished about 422 years before Christ. It is, however, very remarkable, if it be true, that there is no example known of a Greek statue with a ring on the hand.

Reverting to the sculpture under consideration, I find their apparel almost always richly fringed; with wide borders ornamented with figures of men, animals, and foliage. The caparison of their horses is most gorgeous; every strap of their head and body housings is enriched; to the chariot horses there is usually seen attached, apparently either to the extremity of the pole, or to the trappings of the neck, and to the front of the chariot itself, a long fish-shaped piece of drapery, fringed and embroidered. Dr. Layard is at a loss to designate this object. Perhaps, "the precious clothes for chariots," alluded to by Ezekiel as being obtained by the people of Tyre from Dedan, may have reference to this singular piece of horse-furniture.

The same love of ornament above alluded to is apparent in their pavilions, of which there are specimens in this sculpture; also in the fashion of their armour; the hilts, handles, and sheath-ends of the swords; their knife handles, their slings, and their quivers. There are in the British Museum some lions' feet of bronze, apparently belonging to furniture, which formed part of Dr. Layard's collection at Nimrood, and are equal to Greek workmanship in execution.

The style of art which characterises all these ornaments offers us a subject of curious enquiry. What relation does it bear to other styles? To what extent is it original? And to what extent does it appear to have influenced other succeeding styles known to us? Major Rawlinson, who has fortunately succeeded in mastering to a great extent the difficulties that have hitherto hidden from us the knowledge handed down in the strange characters that cover these and other remains, entertains no doubt that the earlier ruins from whence these sculptures have been derived, bear the extraordinary date of twelve or thirteen centuries before the Christian era. This sculpture, therefore, is probably as old as most of the Egyptian antiquities we possess; yet the style of the ornaments, although certainly partaking somewhat of Egyptian character, is in many respects widely different from it. The borders of the linen wrought in successive stripes, and those stripes subdivided into a succession of squares, is certainly an Egyptian peculiarity, prevalent in this Assyrian costume. Indeed the people of the two

countries, although widely separated from each other, may most probably have interchanged commodities, and goods of so portable a kind as bales of linen may well have found their way from Egypt to Assyria. We have the incontestible and contemporary evidence of Ezekiel, that Egypt furnished "fine linen with embroidered work" to the merchants of Tyre, who it may be presumed supplied the markets of Nineveh. There seems therefore no reason to be surprised at finding Egyptian patterns worked on the dresses of the personages so carefully represented on the walls of the Ninevite palaces, nor can any conclusion be safely drawn from that circumstance that there was any identity of design between the works of the artists of those two countries. It may however be here observed that in the trappings of their horses there is a somewhat strong resemblance between these examples and those afforded by the Egyptian paintings in the British Museum.*

The Honeysuckle ornament so abundantly used in the sculpture before us is, I believe, nowhere seen in early Egyptian work. Nor are there any traces of resemblance between Assyrian and Egyptian design in the beautifully and freely drawn figures of animals so profusely introduced into their work by Assyrian artists. We seek in vain here for those stiff and formal and very peculiar ornaments round the neck, consisting of a continued repetition of strokes of the pencil which we see constantly recurring in Egyptian work, especially on the mummy cases. The Assyrian artist seems to have completely relieved himself from the rigid conventional manner of the Egyptian, and to have acquired considerable facility and freedom of execution: examine the slightly-etched figures of winged bulls and other animals pervading the dresses of almost all the larger figures on this sculpture, and we find them drawn, or rather sketched, in a style that would do credit to the best artists of the present day; and when we consider the enormous extent to which this mode of decorating the walls of their buildings prevailed, not only at Nineveh, but at other buried cities which have been recently explored in the same country, it seems fair to presume that the trifling and very subordinate details to which I have been adverting must have been the work of common and ordinary artizans.

Let us now compare the ornaments under review with the more familiar forms of Greek art: and here I think we find so strong an analogy, and in some cases such a striking resemblance, as to force upon us the conclusion, that the artists of Greece derived far more of their art from the banks of the Tigris and Euphrates than from the banks of the Nile; and Egypt must, I think, relinquish a large portion of the honour that has been so long accorded to her of having been the mother of Greek art. The honeysuckle ornament, already alluded to as occurring abundantly in this sculpture, is both in form and treatment almost purely Greek.

The Guilloche scroll, so characteristic a Greek ornament, occurs very accurately chased on the scabbard of one of the swords of the Assyrian warriors. An ornament much resembling (although not identical with) the labyrinth fret, also appears etched as an ornament on a dress. The classical enrichment, commonly called the bead-and-reel, is here of very common occurrence. The running ornament of animals and foliage grouped together, constantly occurring in this costume, is a perfectly classical feature.

I purposely confine myself to the style of ornamentation visible in these works, and forbear to enter into any similar comparison between Assyrian and Greek sculpture in its higher qualities, for such an enquiry properly falls within the province of the sculptor; but were I to do so, I apprehend we should arrive at the same result. It needs not the professional eye of a sculptor to see in the attitudes and drapery of the figures a regular and progressive, although perhaps a slow, development of art, from these marbles through those of Asia Minor and Sicily down to the works of Phidias.

Whilst inviting attention to the germ and gradual growth of that beautiful system of decoration which has been handed down to us by the Greek artists, and has been the object of imitation during succeeding ages, not excluding even the mediæval age, I am tempted to suggest whether much of it, perhaps almost the whole of it, may not have had its origin in the use of sacred emblems or in the representation of sacred objects.

The Bull was deified in the earliest ages, and we see it carved in profuse variety as an ornament on these marbles. It occurs abundantly in the sculpture of Asia Minor, and in classic art became a favourite ornament. The Lion, also, furnishes us with another very familiar instance of an animal deified by the Egyptians, and introduced by the artist in every variety of form as an ornament. The honeysuckle which, under the wonderful influence of Greek taste, became so beautiful and so universal an ornament, is here found many centuries before the birth of Greek art as representing the sacred tree before which the Assyrian priest is performing his religious rites. The fir cone, which plays so prominent a part in classical decorative sculpture, is in these marbles almost always held as an offering in the hand of the priest. The lotus is another familiar instance. We find it first the object of worship in Egypt, but afterwards converted into one of the most beautiful of all the forms of antique ornament.

The Rosette, or Patera, is perhaps one of the most universal ornaments in the whole range of art. It occurs in the paintings of the Egyptians, and is carved on Hindoo sculpture; it was embroidered on the garments of the Assyrians, and ornamented their armlets, bracelets, and even their whip-handles. Nor on the sculptured remains of Persepolis is it wanting. The rosette is painted on the fictile vases of all ages, from the earliest to the latest, and has ever been one of the most common of all the ornaments of architecture. May I not venture to claim for this form, also, a sacred origin? The winged circle was the emblem of the deity in Egypt, Assyria, and Babylonia. It occurs frequently in the marbles before us, and is usually filled in with what has the appearance of a rosette; but when the circle is large, we find the inserted figure to have a star-like form, or a radiation of tapering flames: may this not be supposed to typify the sun, the great and earliest object of idolatry? Is it not at least a plausible hypothesis that this figure, whether it be a conventional representation of the sun, or a star, may in the course of time have assumed in the hands of the artificer, the varied and beautiful ornament with which we are so familiar?

I may here take occasion to advert to that mystical figure of which Dr. Layard gives us a representation in his work, and of which we have examples in the marbles before us, as well as in those of Persepolis. It consists of a circular figure like a wheel, with rays emanating from the centre; and from this wheel issues the upper part of a man, terminating from the loins downwards in flames; and flames issue from the sides of the wheel, left and right, assuming the general appearance of wings. The general correspondence of this figure with those of the cherubim and the wheels, as described in the visions of Ezekiel (chap. i. and viii.), is too striking to escape observation. It is unquestionably a sacred and supernatural form, occurring, as Dr. Layard observes, usually over the head of a victorious monarch, and may represent a tutelary divinity or an angel. I have already stated that I confine my remarks, on the present occasion to the ornamental details, but the whole sculptures well deserve far more attention than they have even yet attracted, although I am not insensible of the great value of the learned disquisitions published by Dr. Layard. The glimpses which these interesting monuments afford of a primeval architecture are to us especially interesting.

Dr. Layard has remarked with truth on the very wide difference existing between the style of Assyrian architecture developed in these remains, and the architecture of Egypt. There appears here to have been an almost total absence of columns. Dr. Layard gives us a representation of one instance occurring in a *bas relief* found in the ruins of Khorsabad, which he presumes to be of later date than those of Nimrood; and in the slabs in the British Museum one example occurs, wherein three pillars are introduced, but of proportions so slender as to lead to the presumption that they were of wood; a supposition the more probable, as they appear to support, not a horizontal entablature, but the frame-work of a kind of tent: it is worthy of remark, that these pillars have as their capital the horns of the goat so arranged as to suggest at once the Ionic capital, and the Khorsabad example is also of this type.

The absence of columns may possibly be due, in great measure, to the flat, alluvial character of the district between the Tigris and Euphrates, which furnished the soft alabaster of which these slabs are formed, but no hard building stone suitable for columnar architecture. Rooms, however, 35 feet and 40 feet wide, such as occur in the palaces explored by Dr. Layard, would not have been roofed over without a greater degree of constructive skill in carpentry than we have any reason to suppose was possessed in these early ages. Perhaps, therefore, the horizontal beams of which the roof was formed may have been supported by wooden pillars which are now perished, or which may have been burnt when these temples were sacked, a fate which most of them have probably undergone. That pillars were used to support the roof-timbers is the more probable, as it appears that the apartments were lighted from above by apertures in the roof, which would interrupt the

* An architect from Vienna informs the author of this paper that the caparisons of these Assyrian horses strongly remind him of those now used in the southern provinces of the Austrian empire, and the adjacent parts of Turkey.

continuity of the timbers, and render intermediate supports absolutely necessary. It may be asked, why assume that the Assyrians were ignorant of framed trusses, by which the widest spans might be roofed over without the assistance of intermediate supports? We cannot prove the non-existence of trusses, but we certainly have no evidence that such artificial contrivances are of this remote date. We see no indication whatever of pitched roofs in any of the sculptures before us, nor, I believe, at all in Egyptian architecture. Even in the Lycian examples we do not find, until we come down to the Greek period of art, any example of a pediment, which is but the gable end of a pitched roof. These Assyrian palaces, then had, I presume, flat terraced roofs, as we know the Egyptian buildings had: it is the present fashion of the east, and that it has ever been so there is abundant proof in the Scriptures. It was a law of the Jews that no roof should be built without a parapet, so that those walking thereon might be rendered safe. In the sculpture before us are various representations of small domestic buildings; they have no sloping roofs, but are rounded at top as if formed of slight timbers bent round, which were probably wattled over and covered with mud like the wigwams of the present day. The pavilion, also, to which I have already adverted, appears to have had its covering stretched over similarly bent timbers. It does not seem improbable that the curved and pointed roofs of the Lycian tombs own a similar type, and are a marble version of a roof of bent timbers.

Dr. Layard discovered no indications of windows in any of his excavations; but that windows were used in Assyrian architecture is proved by the representation of them occurring in many of the slabs: nor can we imagine any other mode of gaining daylight in the lower rooms when buildings were of several stories in height, which, by these *bas reliefs*, appears to have been the case. These windows are square-headed, generally, and have the peculiarity of a double or rebated external reveal, by which means, like the splay in Gothic architecture, additional light was gained, the actual apertures being narrow. This square sinking in the jambs of a window are, I believe, without a parallel in Egyptian architecture, and is not seen in purely Greek buildings; but it is singular that this is a feature pervading the very ancient tombs of Asia Minor, recently made known to us; many instances of it occur in the Xanthian marbles at the British Museum. Whatever may be the date of the marbles from Xanthus, they certainly appear to be a very remarkable link between Greek art and some other very different, pre-existing style.

The occurrence of circular-headed openings in the fortified buildings of Assyria, as plainly represented on these *bas reliefs*, dissipates at once all ideas formerly entertained of the comparatively recent discovery of the principle of construction. Dr. Layard mentions a brick vaulted chamber which he brought to light among the ruins of Nimrood, and other similar discoveries are reported to have been still more recently made by him. It seems a reasonable conjecture that the Arch may have been first used in an alluvial country like that of Assyria, where abundance of bricks were made, and where the difficulty of transporting from remote distances large blocks of stone, fit to form a straight lintel over a wide bearing, would render the substitution of an arch turned with bricks, or small stones, peculiarly convenient.

We may notice that tubular drain tiles were used in removing the rain-water that fell through the openings in the roofs, on to the pavements of the several apartments. That so obvious and simple a contrivance should have been resorted to by a people possessing great dexterity in the fabrication of fictile ware, and living in a district where the common soil of the country furnished the materials to their hand, seems so natural as scarcely to justify more than a passing remark; yet, is it not curious, that now, in the nineteenth century, and in England, a tubular draining tile is one of the most recent of novelties?

A thin stratum of bitumen is mentioned by Dr. Layard as occurring under all the floors, and passing, as he observed, under these sculptured slabs of alabaster with which the inner face of the walls was lined. He was unable to account for this, but the architect will at once perceive that this was a precaution taken to prevent the damp from arising from the earth under the pavement, and destroying the paintings, and endangering eventually the alabaster itself.

Reverting again to the representations of Assyrian Castles on the slabs before us, I must not omit to call your attention to the crenellated parapets having battlements generally pointed or notched, as if to facilitate the use of the bow and arrow. Here also we find an analagous case in the friezes of the Lycian temple, discovered by Sir Charles Fellowes, and now deposited in our Museum. Castles are there represented with embattled parapets very similar to these in Assyria, and not unlike examples still subsisting in the East.

It has long been a subject of speculation what style of architecture characterised the first temple of Jerusalem. I think that it may be not unreasonably presumed, that the magnificent ruins now brought to light, after an interment of two or three thousand years, afford us a far better clue than any we have ever yet possessed; a much more intimate connexion existed, both geographically and politically, between the inhabitants of Palestine and the people of Assyria and Babylonia, than with the Egyptians, from whom they were separated by the Arabian desert. Perhaps, too, the marbles under discussion will be admitted as evidence of an earlier civilisation of art among the former people, and therefore of their greater influence in matters of taste. We have indeed the evidence of the Scriptures that Solomon sought his artists—his "cunning workmen"—in the region north of Judea; Hiram of Tyre was his worker in metals, and his best carpenters were Sidonians.

With how deep an interest, then, these considerations seem to invest the sculptures from Nimrood! When, to use the eloquent words of Dr. Layard, we reflect that "Before these wonderful forms, Ezekiel, Jonah, and others of the Prophets stood, and Senacherib bowed; that even the Patriarch Abraham himself may possibly have looked upon them:" that works of such extraordinary interest and value should, after the lapse of thousands of years, have found their place in our National Repository, is indeed a matter of just pride and congratulation, and I cannot forbear to express a confident hope that no exertion may be wanting on the part of our rulers, and of the nation generally, to second the indefatigable zeal of our countryman in securing for us a still farther accession to this most important collection.

In conclusion, Mr. Smirke referred to the recent accounts from Nineveh, as being provokingly vague and meagre. There had been found, it would appear, a most miscellaneous collection of rich armour, antique vessels, costly apparel, and other treasures, put together in a manner perfectly perplexing. An ingenious pupil of his, Mr. Cates, had, however, drawn his attention to a passage in Diodorus Siculus, which would perhaps help to explain so otherwise unaccountable a circumstance. Sardanapalus, as they all knew, when his danger was imminent, and the Median enemy in possession of his city, owing to a sudden irruption of the river breaking down twenty stadia of the walls, collected together all his vestments and treasures, and formed of them a grand funereal pile. On the top he placed his concubines, his eunuchs, and himself; and, applying the torch, the whole were burnt together. Diodorus relates that one of the eunuchs made his escape, and gave information to Belesys, a Babylonian priest, that under the ruins of the king's palace might be found enormous treasures. The priest went straight to Arbaces, who, in the midst of his triumph, was distributing rewards to his satraps, and reminding the monarch that he had predicted the fall of Nineveh, said that in the midst of the battle he had vowed a vow to Belus, that if the Babylonians were victorious, he would convey the ruins of the royal palace to Babylon, and erect there a temple to that god, which should at once serve as a landmark to those who navigated the river that ran by that great city, and be a monument of the destruction of Nineveh. The Median king, who was described by Diodorus as possessing a noble and generous disposition, granted to Belesys all the ruins of the royal palace for this purpose. The priest then, with the help of the eunuch, removed a greater part of the treasure; but the fraud was discovered, and he was condemned to death. The operations of the priest, so far as the treasures were concerned, were surreptitious, and of course the investigation of the ruins could not have been so complete as if it had been conducted openly and deliberately, and that would seem to account for the incongruous heap of valuables discovered by Dr. Layard. Thus, if the eunuch had not had so natural a distaste to be one of the party in the royal *auto-da-fe*, Dr. Layard might have been by this time in possession of all the treasures of Sardanapalus.

Remarks made at the Meeting after the Reading of the foregoing Paper.

Mr. Bellamy (the Chairman.)—Our best thanks are due to Mr. Smirke for his interesting paper on this highly interesting subject. I may mention, as an addition to the paper, that I have noticed in these sculptures the apparent existence of folding doors. I cannot help expressing a wish that these excellent sculptures may be speedily removed from the cellar which they at present occupy, to a better position, where they may be seen to greater advantage.

Mr. Donaldson.—There cannot be a doubt but that Dr. Layard has at Nimrood brought to light a class of architecture or style of art, which prevailed not only on the banks of the Tigris, but also obtained through the

extensive region of country called Assyria, which included Media and Persia. I have here a volume of the 'Universal History,' published in 1747, which contains copies of Le Brun's representations of Persepolis. These engravings show a great number of columns, and a perfect identity, not only of style, but of the objects represented in the bas-reliefs—winged bulls and lions, crowned with a sort of cap, divinities, &c.—drawn more than one hundred years ago. There are also bas-reliefs with long lines of personages in procession, exactly in the same style of costume as those to which Mr. Smirke has drawn our attention. The figure, which he supposes to be a tutelary divinity, is likewise here represented as being common on the tombs in the neighbourhood of Persepolis, exactly in the same way that they are represented in Egyptian antiquities. The kings of Persia used to reside alternately, according to the season of the year, at Babylon, at Susa, at Ecbatana, and at Persepolis; at all of which places the same character of style and art would prevail. I am therefore inclined to the supposition, that the architectural remains now brought under our notice form but one of a class, which was spread over the whole country; a fact which I think would be more obvious, if we had equally excellent illustrations of the ruins of Persepolis, as of those now before us. The winged lions from Nineveh, now in the British Museum, are crowned with a sort of cap commonly found upon the sphinxes in Egyptian remains; and it is remarkable that the bulls from Nineveh agree exactly in size with those at Persepolis, both being about 22 feet long and 14 feet high. That is another sign of identity, and I conceive the material will furnish another. These remains are said to be of alabaster, and that was a material frequently used in Egypt, as witness the sarcophagus in Sir John Soane's Museum; and, indeed, throughout our own Gothic period. For architectural ornament, or sculptural devices and figures, the use of alabaster has been extensive in all periods of art. I cannot agree with our friend, that Israel had more to do with Assyria than with Egypt; as the latter is mentioned much more frequently than the former in Holy Scripture; and, it will be remembered, the aid of the Egyptians was called in to resist the Assyrians, who in the end actually carried the Israelites away captives. At an earlier period, too, Solomon married the daughter of Pharoah. There was, besides, a greater affinity in the art of Israel to that of Egypt, rather than to that of Assyria. There must, too, have been a great enmity between the Persians and the Egyptians, for Cambyses invaded the latter, destroyed the temples of Thebes, slew the god Apis, and dishonoured the tomb of Amasis, king of Egypt; and, therefore, the Israelites could not very well have been friendly with both. Dr. Layard says it is probable that Abraham saw these sculptures, but I doubt that the Holy Scriptures justify this supposition. We know that there were pyramids in Egypt one hundred years before the death of Noah; and it has always been the practice to assign a higher antiquity to Egyptian architecture than to Assyrian. I am myself of opinion, that there is in these sculptures signs of a depreciation from the simple principles of an incipient and rising art; and that it is rather a degraded phase of Egyptian art, than a new and original class. In conclusion, Mr. Donaldson proposed a vote of thanks to Mr. Smirke, and also to Mr. Murray, for the illustrations with which he had favoured the Institute.

Mr. Smirke remarked that the representations of the Persepolitan sculpture were very imperfect. The best were those of Sir Robert Porter; but even he was not a very careful draughtsman. He hoped the time would soon come when they may be as well known as those of Assyria. With regard to the connection of Israel with the countries of Egypt and Assyria, it must not be forgotten, that although Solomon married Pharoah's daughter, he sought his "cunning workmen" and the materials for his great architectural works in the opposite direction. He begged to repeat his decided conviction that the Assyrian marbles bear a much more marked affinity with the succeeding Greek style of art than that of Egypt.

The Chairman thought he could detect a knowledge of perspective in Assyrian architecture; and in some instances there were indications which would lead to a supposition that they had also a knowledge of the principle of the arch.

Mr. C. H. Smith said these marbles were said to be alabaster, but that conveyed a wrong impression, as he believed they were not alabaster proper or sulphate of lime. He had slightly examined the Assyrian marbles, and believed them to be carbonate of lime. Dr. Buckland had, he knew, said they were alabaster, but the Doctor had told him that he had not examined them closely.

The Chairman said that he believed one was a conglomerate or freestone.

Mr. Ferguson said that the members did not seem to be aware that the French had sent to Persepolis, and had copied all the sculptures discovered there to a very large scale and with great accuracy. The drawings were much better, he should say, than those now exhibited of Nimroud, and that they gave more details, and were more complete in every way. The last letters from Dr. Layard announced that he had discovered the throne of the King, upon which there was not the slightest trace of fire. It was composed principally of ivory with gold ornaments. There were traces of cloth trappings; and the gold thread with which it was sewn and embroidered still remained. This throne had been found in the same ruin as that which contained the miscellaneous collection of valuables already alluded to, but not in the same chamber. The condition of the articles discovered proved indisputably that that palace had never been destroyed by fire. Major Rawlinson had, however, satisfactorily determined that Nimrood was not Nineveh; that city had not yet been excavated. The name of Jonah having been found at the onset on the ruins, no further excavations were allowed by the Mahommedans on that spot. The attachment of the horses to the cars in these sculptures, which seemed to occasion some difficulty, was easily explainable, inasmuch as it was in common use in India to this day. The pole comes from the axle, and a sort of platform is carried on till it meets the yoke. That is always covered in India with red cloth, ornamented in the same way as appears in the sculptures. The upper part is a platform on which the driver can sit. In answer to the remarks made upon the honeysuckle ornament, it appeared to him quite clear, that the Ionic was derived by the Greeks from Asia, and the Doric from Egypt. Thus in these marbles there was no trace of Doric, but everywhere traces of Ionic, for in Egypt the Doric was found all the way from Nubia down to the caves of Memphis. His opinion was confirmed by that of all the greatest authorities.

Mr. Scoles remembered during the whole course of the Nile, from the second cataract downwards, but two instances of anything like Doric columns, and they were simply fluted cylindrical shafts without proper capitals.

Mr. Ferguson.—Yes, they have the square abacus.

Mr. Scoles wished to ask his friend Mr. Smirke, whether he considered this an architecture *sui generis*, and if not, whence derived ?

Mr. Smirke.—If not indigenous, it is impossible to say whence it was derived, for we are unacquainted with any earlier style of architecture.

Mr. Fowler said that the bull taken in the Burmese war was engraved with ornaments, just as might have been supposed to have been executedin the best days of Greek art. There was upon that the honeysuckle ornament found on these Assyrian remains.

Mr. H. B. Garling asked why Mr. Smirke supposed these details were not executed by skilled artists ?

Mr. Smirke.—Because they are so numerous that a master hand could not have been engaged upon them all. They are sketched with the utmost profusion over the whole of these sculptured remains.

TOWERS AND SPIRES OF THE MEDIÆVAL PERIOD.

Some Observations on Towers and Spires of Churches of the Mediæval Period. By John Britton, F.S.A.—(Paper read at the Royal Institute of British Architects, April 8th.)

Mr. Britton addressed the meeting nearly as follows:—"Mr. President and Gentlemen,—I am induced to appear before you on the present occasion, most probably for the last time, to call your attention to the interesting series of drawings now exhibited, which have been made by Mr. Wickes, architect at Leicester, who has devoted much time, skill, and perseverence to a task which he has entailed upon himself, *con amore.* How far he has succeeded in the execution of that task you will be enabled to judge by a cursory inspection of the drawings. Had I not believed that they were worthy of the attention and admiration of this learned and scientific body, I should not have obtruded them on your notice; but satisfied as I am of the interest attached to the subject, and of the accuracy and skill manifested in the drawings; and believing also that the various towers and spires of Great Britain in particular, and of the civilised world in general, are entitled to the diligent study of the architect, and the admiration of the antiquary, I volunteer my weak and humble services in thus introducing a provincial member of the profession to the Royal Institute of British Architects.

Before alluding further to his deliniations, I gladly avail myself of the present opportunity to acknowledge and thank this society for the honour and compliment which they paid me at its formation, by electing me as the first honorary member. Though it has been to me a source of pride and pleasure to receive similar compliments from several other societies devoted to architecture and archæology, I must own that I never derived so much gratification from any of them, as from this proof of the esteem of the architects of London, with many of whom I had been intimately acquainted for years. To have secured the approval of such a body of artists, and to receive from them a voluntary testimony of their regard by that election, surprised and delighted me. The only thing I have regretted has been, as it still is, my inability to render that assistance to the society which I have always wished to do, but which other pressing demands on my time have prevented. In the progress and prosperity of the Institute I have always felt deeply interested, and therefore hail with much delight the position it has attained—not only in our own, but in foreign countries. May it long continue to prosper, and thereby confer

honour on all its members, generally and individually; may it give to English architecture a character and dignity rivalling, not merely that of classical and mediæval antiquity, but of all co-existent nations in the world;—may laudable rivalry—divested of envy and all other bad passions—govern and be diffused through the society;—and may all its councils and proceedings be characterised by liberality of sentiment and action, and by devotion to the credit and welfare of the profession."

Mr. Britton then read part of the following paper which he had prepared for the occasion; but weakness of the organs of the throat, from long illness, rendered him unable to go through the whole.

In the subdivision, and in the distinctive parts of churches, there is not one which more strikingly contra-distinguishes the buildings of the mediæval age from those of the Pagan world, than the Tower, Steeple, and Spire. This marked feature of a church was invented by the earliest Christian architects, who in the first place designed and raised a plain, simple, and rude pile, small in size, and devoid of of all ornamentation. In every succeeding age and era they produced changes and improvements in this architectural member; and it is equally evident, that every architect invented something new in form, proportion, and detail, in each and every new tower that was progressively erected. I believe, it may be safely said, that there are not two of these buildings in England precisely alike.

It has been erroneously supposed by writers on mediæval architecture, that the employment of spires, or pyramidal terminations of towers, was a consequence of the introduction of the pointed arch; and that the towers of churches, erected before that important era in the history of architecture, were designed to be perfectly flat at the top. This mistake has arisen from the circumstance, that the most ancient towers have lost their original finish; some being now covered with flat roofs; others having spires, pinnacles, and certain appendages of much later date; scarcely any, indeed, remaining unaltered at the present time. But if we examine the representations of churches in ancient drawings, and on seals,—a species of evidence of the greatest possible value,—we find that spires were very common in the eleventh and twelfth centuries; and even among the Anglo-Saxons long before. The engravings from ancient Saxon MSS., in the works of Strutt, comprise many spires, finished with crosses and weathercocks; and the well-known drawing of Canterbury Cathedral, made by Eadwin the monk before the destruction of the church by fire, in 1174, displays no less than five spires on the church itself, besides some on the out-buildings. Compared with those of the fourteenth and fifteenth centuries these primitive spires were very clumsy; they were square in plan, and either covered with lead, tiles, or shingles; and the loftiest were not more in height than twice the diameter of their base. Two ancient spires of this form remained till the beginning of the present century, on the western towers of the collegiate church of Southwell; and there are still two small ones at the angles of the west front of Bishop's Cleeve church, Gloucestershire. A great improvement was effected in the form of spires, by reducing them to an octangular shape; though the earlier examples of that kind had still a square base, the angles being sloped upwards to the spire. By this alteration, though their height was not actually increased, they had an appearance, when viewed at an angle, of much greater loftiness. There are many stone spires of this kind in Lincolnshire and in the adjacent counties.

Though the builders of stone spires appear to have been cautious of increasing their height, those of timber soon assumed a great altitude with proportionate elegance of form; and were at length made of much less breadth than the towers on which they were built, and with a degree of slenderness never attained in stone. There is a fine timber spire at Long Sutton, Lincolnshire; and one of the earliest stone spires is at Sleaford Church, in the same county.

Stone spires, as well as those of timber, were gradually reduced to a more slender proportion. In the fourteenth century their angles were decorated with crockets; and the pinnacles at the angles of the tower below were frequently connected with the spire by arch or flying buttresses.

The forms, proportions, and details of Towers and Spires were infinitely varied and diversified. They were most usually placed at the western end of churches; and some of the larger and more elaborate edifices,—as York, Lichfield, Canterbury, Lincoln and Wells Cathedrals, have each two towers at the west end, and a third at the centre, or intersection of the nave and transepts. In Lichfield Cathedral each of the three towers is crowned by a lofty and elaborate spire. Exeter Cathedral presents the unique example of a tower at the extremity of each transept.

The Towers of churches are either square, round, or octagonal; the first being the most frequent. Large doorways and windows, buttresses, stringcourses, and other decorations diversify them. In some examples (as at St. Mary's, Cheltenham; Almondbury Church, Gloucestershire; the church at Reculvers, Kent; and many others), the bases of the spires cover the whole upper surface of the tower. Occasionally, indeed, they form projecting eaves; but at a later time the tower was separated from the spire in a marked manner, by a parapet, either plain, embattled, or perforated. The buttresses forming the angles of the tower were terminated by elaborate turrets, or pinnacles, the whole forming a richly ornamented group.

There are numerous towers of all ages *without* spires; and some (as at Ely Cathedral, and the churches of Fotheringay, Northamptonshire, and Boston, Lincolnshire), are terminated with octagonal turrets, or lanterns. At Sutton Benger Church, Wiltshire, is a plain square tower, with a rich embattled parapet. From each angle of the parapet rises a small pinnacle, whilst the *centre* of the face of the tower sustains another, somewhat larger, and of florid decoration, but more diminutive than the ordinary *spire*.

The towers of the Somersetshire churches present many beautiful and interesting characteristics, worthy of the ages of Henries VI. and VII.

It would be irrelevant to the present purpose to advert to the fine and elaborate towers and spires of Continental churches and cathedrals;—those of Antwerp, Strasburg, Freiburg, St. Stephen's, Vienna, and Malines, will readily occur to the memory of the architectural student.

In more remote connection with the subject, the Round Towers of India, of Ireland, and of the eastern counties of England, the Keep, and Bastion Towers of ancient fortresses, as well as the Tower Gate-houses of old English cities, claim a passing allusion; as at a more favourable opportunity they would well repay attentive consideration and lengthened comment.

It cannot fail to be a subject well worthy investigation and illustration, for an architect to inquire into the history, peculiarities, construction, design, and endlessly-varied features of towers and spires, and also to prepare such a series of drawings as would clearly and amply illustrate the progressive improvements made in this department of the architect's professional career.

Actuated by a laudable desire to accomplish a publication of this kind, Mr. Wickes, of Leicester, has visited several of the cathedral, collegiate, and parish churches of England, and made drawings of their interesting towers and spires, which he proposes to have lithographed and published. In a prospectus which that gentleman has issued, he mentions his intended work as "a desideratum in the history of our national architecture." He adds, with equal truth, that "among the many beautiful and striking relics of mediæval art scattered throughout the land, the spires and towers of our churches stand pre-eminent for richness, variety, and elegance, and hence deservedly claim the tribute of our praise and admiration. Reared by the hand of genius, and dedicated by the spirit of piety, these stupendous fabrics,—

"Point as with silent finger to the sky and stars;"

and after the lapse of centuries remain to bear indisputable evidence to the taste and skill of our ancestral architects. The grandeur of their composition, and the fineness of their outline, their exquisite proportion, richly sculptured ornament, and yet chaste detail, display the astonishing invention and æsthetic ability of their designers; no less than the boldness of construction and scientific arrangement of thrust and counterpoise attest their wonderful skill, and the proficiency to which they had attained in the study of architectural dynamics."

Some of Mr. Wickes's drawings are now exhibited; and should the profession and the public be disposed to patronise his undertaking, he will be enabled to publish a series of illustrations, sufficiently numerous to characterise all the leading varieties of tower architecture in England.

In order to direct the attention of the present meeting more particularly to the subject, I have ventured to offer these few remarks on the leading peculiarities of ancient ecclesiastical towers and spires.

Remarks made at the Meeting after the Reading of the foregoing Paper.

Mr. Godwin thought the drawings now exhibited beyond all praise. If any proofs were required to refute the assertion of a recent writer, that all parish churches displayed bad architecture, the series of drawings now before the meeting would do that most triumphantly. The towers and spires of England, commencing with the Norman and ending with the early English

period, exhibited invariably a wonderful beauty and exactness of proportion, and a marvellous grace of outline. The spires of the latter period he had mentioned, presented a variety of character which was most extraordinary, considering how few were the elements at the command of the architects. They had only the square, the sexagon, and the octagon, and yet there were not two steeples to be found at that period precisely alike; while their outlines had a power and beauty, which completely disproved the assertion, that all the old parish churches of England were bad Gothic. While on this subject, he wished to draw attention to the miserable condition of many towers and spires throughout England. A remarkable instance was the tower of St. Mary's, Taunton. The interior of that edifice was fitted up at a large cost a few years ago by Mr. Ferrey, fellow, but the tower was left untouched, and it was now in a wretched state of dilapidation and decay from top to bottom. St. Stephen's, Bristol, which had a curious arrangement of open work, similar to that at Taunton, was also in a decayed state; but dilapidation itself was even better than some modes of repair. He had been on the day previous at Dundry, a village in Somersetshire, four or five miles from Bristol, and the church tower there had open work at the top, something like that at St. Stephen's, Bristol but yet possessing interesting peculiarities of its own. The upper part of the tower falling into decay, an architect was consulted, who recommended the rebuilding of the decayed portions, at a cost, which he estimated would be about 300*l.* The parish blacksmith, however, who, being one of the vestry, was all powerful, said he could mend it for 40*l.*; and accordingly he had encased it with the most amusing elaboration of iron net-work ever beheld. Cross bars of iron traversed the tower in every direction, and this mode of repair would in a few years hasten the whole pile to destruction. The tower, which was a beautiful specimen of the style common in the sixteenth century, was in a good state, except the top; and he repeated, that the means used for its repair must inevitably in a few years destroy the whole. It was, indeed, most important that parish authorities should listen to that which was repeated almost every day, namely that they ought in such cases always to call in proper professional advice, and not merely call it in, he would add, but take it.

Mr. Tite.—I am glad, and I am sure all here present are delighted, to see our old friend Mr. Britton, again amongst us. Let us hope it is a pleasure which will again gladden us. Our friend states that Mr. Wickes is anxious to publish the series of drawings, in outline here exhibited. Every artist would desire to see them published in outline; to the profession that would certainly be the most useful and acceptable form. As a group of buildings they are honourable to the country and to our native architecture. I do not think that any other country in the world could furnish the originals for such an admirable series of drawings as those now exhibited. There are few countries that could match, or at least excel, any of them in beauty. In all Normandy, I only remember one church which I could describe as worthy to be ranked with these; that was at Lillebonne, a town famous for Roman remains; and I was delighted to find, on inquiring after its architect, that it was attributed to an Englishman, who had settled permanently in that part of the country. I mention the circumtance as a proof that English church architecture has a distinctness of character, which would almost of itself constitute a separate school of the art.

Mr. Fowler alluded to the peculiar characteristics which prevailed in the towers of churches in different parts of England. This point had, no doubt, struck other gentlemen, and he should like to hear a dissertation upon it from some one, if not from Mr. Britton. In Devonshire, Somerset, and Wilts, there were general peculiarities clearly traceable, which had no connection whatever with any feature of the country round about. Mr. Godwin had referred to the church at Taunton. He had long resided in that town, and was well acquainted with that splendid specimen of architectural taste, the tower of St. Mary's, although he confessed it was not until he had diligently compared it with others, that he became convinced that it was the most beautiful tower of that class in all England, and it presented as curious a network of iron bars as he saw at Dundry. He quite agreed with Mr. Godwin, that the introduction of iron into masonry could not fail to be attended with injurious effects. He trusted the attention of the public would be called to the subject, and steps would be taken to restore and preserve St. Mary's, Taunton, to the condition in which its excellence entitled it to be maintained.

Ruins of an Ancient Californian City.—Antiquaries will feel deeply interested in the discovery of vast regions of ancient ruins near San Diego, and within a day's march of the Pacific Ocean, at the head of the Gulf of California. Portions of temples, dwellings, lofty stone pyramids (seven of these within a mile square), and massive granite rings or circular walls, round venerable trees, columns and blocks of hieroglyphics—all speak of some ancient race of men now for ever gone, their history actually unknown to any of the existing families of mankind. In some points, these ruins resemble the recently discovered cities of Palenque, &c., near the Atlantic or Mexican Gulf coast; in others, the ruins of ancient Egypt; in others, again, the monuments of Phœnicia, and yet in many features they differ from all that I have referred to. I observe that the discoverers deem them to be antediluvian, whilst the present Indians have a tradition of a great civilised nation, which their ferocious forefathers utterly destroyed. The region of the ruins is called by the Indians "the Valley of Mystery."—*American Correspondent.*

THE ENTASIS OF A COLUMN.

Description of a method invented by Mr. Jopling for describing the Entasis of a Column, or Spire, and some other Curves adapted to Architectural Lines. By F. C. Penrose, Esq.—(Paper read at the Royal Institute of British Architects, March 18th.)

There are few gentlemen here, who will not allow, that a curve of strictly varying curvature is more beautiful and appropriate than one, like the false ellipse to which I point, which is made of several circles, each mutilated segment of which suggests its own completion, and interferes with the general line composed of the several arcs. And no one will deny, that, if it can be shown that varying curves can be constructed easily, we ought to apply them whenever possible, instead of the broken lines so often used. I was led in following out an examination of the curves used by the Greeks, to endeavour to invent an instrument for drawing by continued motion the hyperbola, a curve frequently used by them in the profiles of their mouldings, and the entasis of their columns; and I succeeded in arriving at an instrument, which, by a very slight modification of the method of drawing the conchoid of Nicomedes, of which I produce some examples, draws the hyperbola with the greatest exactness. I had not gone far in this study, before I found that Mr. Joseph Jopling had made many valuable discoveries in various methods of drawing curves by machinery, the principles of some of which he has recently published in a small pamphlet, named the 'Impulse to Art.' In this he describes a method for drawing the Ionic volute by a particular and simple arrangement of three cranks, or a crank and two strings, like the instrument I lay before you; and by another arrangement of the same instrument, he produces a very beautiful ogee, called by him the line of beauty, of both of which he has lent me specimens of a large size, drawn by him to lay before you this evening. I was enabled by applying his method deduced from the 'Impulse to Art,' without any assistance from him, to arrive at so near an approximation to the volute of the Ionic column of the Propylæa, of which Mr. Willson and I obtained exact measurements at Athens, that I can hardly resist the conclusion that Mr. Jopling has discovered the method used by the Greeks in drawing their volutes. He assures me that he has found equally, if not more, satisfactory comparisons from the volutes of the Erechtheum and other buildings.

What I have chiefly undertaken to bring before you this evening, is a method for drawing the entasis of a column, or a spire. We suppose it to be granted (which perhaps is not absolutely certain) that a spire ought to have an entasis. It probably depends upon the effect we wish to give to the spire, whether it should be straight-sided, or have the usual convex entasis, or concave entasis, as the latter may be called where the sides are hollowed. Mr. Jopling's instrument, which is very simple, is equally adapted to either case. It consists of two principal parts: a flat straightedge, the sides of which, instead of being parallel to one another, diminish at a small angle; the one for instance which I produce, is 3 feet 6 inches long, at one end $3\frac{1}{2}$ inches, and at the other $1\frac{1}{2}$ inch broad. The other part is a bar with one fixed peg at the end, and two moveable sockets, one of which carries a peg, the other a pencil tube. Nothing more or less than the bar of an ordinary trammel and the tapering straightedge: it is the same in principle as the trammel, only much more convenient for the drawing of very flat ellipses than that instrument in its ordinary construction. This might be applied full size to the column or spire, with great ease, though it may be questioned whether that be really so good a way as that of obtaining the curves more at ease, and setting them off from straight directing lines. In drawing the entasis however on paper, to any attainable size, its action is most simple. To produce a very flat ellipse, we have only to set the two pegs at some convenient distance, rather greater than the broader part of the straightedge, and the pencil at some convenient distance along the bar. By sliding the bar along the straightedge, keeping the two pegs in contact, and the pencil on the paper, which is, after a little handling, very easy to do, with proper elbow room and other convenience of standing room, we produce a portion, nearly the half, of an exceedingly flat ellipse; the part nearest the vertex having very sharp curvature, and the parts removed from it being almost straight: so that by a proper selection of a portion of this arc, we may obtain a curve of whatever variety we please, constantly varying also its curvature according to a regular law, altogether superior to anything that can be put together by parts of circles and straight lines, for those purposes at least to which it can be applied.

There are numerous other forms of curves, that could be advan-

tageously applied to architectural purposes, several of which Mr. Jopling has produced. One, which I here point out, is described by an instrument devised by myself, and which draws very complicated forms, available for some purposes in their entire state, and for others by a proper selection of parts, so as to be made applicable for the curves of vases and other lines, and these always suggest beautiful motives for lines of varied curvature. On the present occasion, however, time does not allow me to enlarge upon them, and I must conclude by again calling to your notice the extreme simplicity of the instrument, which Mr. Jopling's kindness has allowed me to lay before you, and which is most readily adaptable for drawing what is often required in Architecture, a long line departing very little from a straight line, and yet with an almost unlimited variety in its curvature.

MOTION OF WATER IN PIPES.

On the Motion of Water in Conduit Pipes; on Friction and Pressure in Pipes; and on Jets d'Eau. By M. D'AUBUISSON DE VOISINS, Ingenieur en chef Directeur au Corps Royal des Mines, &c. &c. —(Translated by T. HOWARD, for the *Civil Engineer and Architect's Journal.*)

(*Continued from page* 132.)

Equation where Conduits are terminated by Adjutages.

12. We have hitherto considered conduits as entirely open at their further extremity; whereas, they are generally terminated by nozzles or cocks, or have some kind of adjutage which contracts the opening, and makes the water issue forth with a velocity different from the uniform motion of the fluid in the pipe: consequently, the equations (I. to XII.) based upon the supposition of identity of velocity, do not apply except under that condition. The first member of these equations, $H - \cdot155v^2$, gives the portion of the head destroyed by the resistance of the conduit; which portion is the entire head H, minus that which remains to produce the velocity of discharge (2): if this velocity is called V, the first member of the equation will, in general, be $H - \cdot155\,V^2$. The second member is the expression of the resistance of the sides (7), which is a function of the velocity in the conduit, or of v; v ought then to remain as it is in this member, which will not change in value.

13. In conduit pipes, even more, if possible, than in other cases of fluids with unbroken continuity of motion, the velocities, at particular points, are in inverse ratio to their sections: so that if d be the diameter of an adjutage at its discharging orifice, m the coefficient for its particular contraction, D being invariably the diameter of the conduit, we have

$$V : v :: \pi' D^2 : \pi' m d^2; \quad \text{or,}$$

$$V = v\frac{D^2}{md^2} = 1\cdot273\,\frac{Q}{D^2} \times \frac{D^2}{md^2} = 1\cdot273\,\frac{Q}{md^2}.$$

The equation for the movement then becomes

$$\left.\begin{array}{ll} \text{[In mètr.]} & H - \cdot08264\,\dfrac{Q^2}{m^2d^4} = \cdot002221\,\dfrac{L}{D^5}\,(Q^2 + \cdot0432\,QD^2) \\ \text{[In feet.]} & H - \cdot02519\,\dfrac{Q^2}{m^2d^4} = \cdot000677\,\dfrac{L}{D^5}\,(Q^2 + \cdot14173\,QD^2) \end{array}\right\} \ldots\text{(XVI.)}$$

Of the five quantities which this equation contains, four being given, we may by it obtain the value of the fifth.

It is required, for example, to determine the diameter necessary to give to a circular orifice in a thin plate, fitted to the end of a conduit of ·08 feet diameter, and 532 feet long, the quantity of water to be discharged per second being ·02 feet, and the head 4·5 feet. The above equation will give

$$d = \sqrt[4]{\frac{\cdot02519\,Q^2D^5}{m^2\{HD^5 - \cdot000677L(Q^2 + \cdot1417QD^2)\}}}.$$

Puttting in the numerical values $m = \cdot62$, and reducing and extracting the fourth root, we have $d = \cdot0477$ feet.

14. For velocities above 2 feet per second, we have (all being in feet),

$$H - \cdot02519\,\frac{Q^2}{m^2d^4} = \cdot000711\,\frac{LQ^2}{D^5}; \qquad \text{(XVII.)}$$

$$Q = 37\cdot034\sqrt{\frac{HD^5}{L + 35\cdot47\dfrac{D^5}{m^2d^4}}}; \text{ and} \qquad \text{(XVIII.)}$$

$$D = \cdot235\sqrt[5]{\frac{LQ^2}{H - \cdot02519\dfrac{Q^2}{m^2d^4}}}. \qquad \text{(XIX.)}$$

Ex. 1.—To a conduit of the dimensions given below, we will adapt a conical adjutage ·03 feet diameter: we require to know the quantity it will then discharge?

Here $D = \cdot25$ feet; $L = 1450$ feet; $H = 5\cdot32$ feet; and for the coefficient for the convergence of the adjutage we take ·90. Consequently,

$$m^2d^4 = \cdot0000006561; \quad \text{and } 35\cdot47\frac{D^5}{m^2d^4} = 52795.$$

$$\text{Then } Q = 37\cdot034\sqrt{\frac{5\cdot32\,(\cdot25)^5}{1450 + 52795}} = \cdot01146 \text{ cub. feet.}$$

The complete equation (XVI.) would also give ·01146 cub. feet.

We would here remark, that if instead of an adjutage of ·03 feet diameter, we put one of ·125 feet diameter (half the diameter of the conduit), the discharge will be .. .. ·06551 cub. feet.

With a diameter of ·1875 feet (¾ diameter) . .. ·06881 cub. feet.

Without any adjutage, we should have .. .. ·06917 cub. feet.

These results show, that when the diameter of an adjutage is great compared with that of the conduit (so as to be more than half thereof), the discharge differs very little from that which we obtain by leaving the conduit entirely open.

In several of my experiments on the conduits of Toulouse, this fact was particularly observed; the difference in some cases was even much less than theory would give—it was imperceptible. For example, having at the end of a conduit of ·164 feet diameter, and 1391 feet long, successively fitted plates pierced with circular orifices, gradually decreasing in diameter, and under a constant head of 53·5 feet, we had the discharges here given. The diameter of the conduit being ·164 feet, the first is the result obtained without any adjutage. We observe that the results of calculation approach so much the nearer those of experiment, as the velocity of the water in the conduit becomes less.

Diameter of Orifice.	Discharge according to	
	Calculation.	Experiment.
Feet.	Cubic Feet.	Cubic Feet.
·164	·07558	·06074
·115	·07417	·06074
·098	·07311	·06074
·066	·06463	·05080
·049	·05192	·04697
·033	·02967	·02896

Ex. 2.—Required the diameter of a conduit 2736 feet long, and from which, with a head of 21·3 feet, we wish to obtain ·4 cub. feet of water per second, by several orifices placed near each other, and which taken together are equal in area to one circular orifice ·13 feet diameter; the coefficient of contraction in this case being taken as ·85?

We have $m^2d^4 = \cdot000206346$; $\cdot02519\,\dfrac{Q^2}{m^2d^4} = 19\cdot547$; and, consequently

$$D = \cdot235\sqrt[5]{\frac{2736\,(\cdot4)^2}{21\cdot3 - 19\cdot547}} = \cdot641 \text{ feet.}$$

ART. II.—CONDUITS WITH BENDS AND CONTRACTIONS.

Three kinds of Resistance in Conduit Pipes.

15. We have been hitherto considering conduits as rectilinear, and of equal section throughout their whole length; but they are generally formed with angles or bends, and occasionally have parts of a diminished section, either over a very small extent (forming, as it were, an annular contraction), or else through a considerable length. Water, moving in such conduits, on arriving at the bends, is compelled to change its direction. In so doing, it loses part of its velocity: the resistance which causes the loss is as a force opposed to the motive power, or the original head; it destroys a part thereof.

At contractions, again, the fluid experiences another resistance: having there to pass through a narrower section, it requires to have a greater velocity; to obtain this, a new effort is necessary—and the consequence is, another diminution of the total head.

Thus, water, in its motion in pipes, meets, or may meet, with three kinds of resistance—that due to the effect of the sides, and which is by far the most considerable; that which arises from bends; and that from contractions. The forces or portions of the head employed to overcome these, lessen the total head; and it is only by reason of the remaining part, that the efflux takes place: this portion is the height due to the velocity of discharge.

We have treated in detail the resistance of the sides (4—8); we shall now examine the other two.

The Resistance of Bends and Angles.

16. Every moving body, which after having followed a certain direction suddenly changes therefrom, loses a portion of its velocity, represented by the versed sine of the angle formed by the two directions. If it moves in a curved line, it is continually changing its direction; but the loss of velocity at each change is only an infinitely small one of the second order; and consequently, although the number of losses be infinite, the total loss will be only an infinitely small one of the first order, or as nothing: in other words, every moving body which arrives tangentially at a curve, and follows it for some length, possesses on quitting it the same velocity it had on its arrival. It follows, that if a bend in a conduit be well formed, and the fluid therein should exactly follow the curve, it would suffer no resistance or loss of velocity.

But this is not the case: the molecules composing the fluid current being independent of each other, while those which are in contact with the sides would follow the curvature, the others, being directed against the sides, will be reflected by them, or by the intervening particles, at an angle which is sometimes very considerable. For example, the central fillet aC has a tendency to strike the side ACB at C, and from thence to be reflected in the direction Cb. The mutual action of the particles on one another, will produce, in the whole, a loss of velocity; it will be, generally, less than that of the central stream taken alone, but always greater than that of the current bordering on the sides.

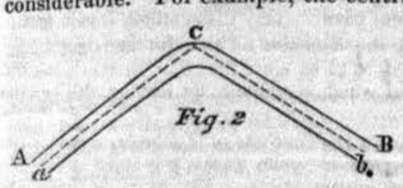


Fig. 2

This diminution of velocity, and consequently of discharge, although certain, will yet be very slight. Thus, Bossut, with a pipe of 1·06 inch diameter, and $53\frac{1}{4}$ feet long, laid horizontally in a straight line, and with a head of 1·07 feet, obtained a discharge of ·7360 cubic feet per minute: then having bent it in a serpentine form, so as to have six well rounded curves, all else remaining the same, he obtained ·7205 cubic feet per minute.

We may, however, by multiplying and increasing the acuteness of the bends, render the diminution of discharge very considerable. Rennie, with a lead pipe, 15 feet long, and $\frac{1}{2}$-inch diameter, fitted horizontally to a reservoir under a head of 4 feet, obtained a discharge of ·419 cubic feet per minute; then having given the same pipe fifteen semicircular bends, of $3\frac{1}{4}$ in. radius, and again fitted it to the reservoir, the discharge was not more than ·370 cubic feet: so that the fifteen bends reduced the discharge in the ratio of 100 to 89; with a quadruple head, the reduction was in the ratio of 100 to 88.

17. With regard to the laws regulating the resistance of bends, and to its amount, we are indebted to Dubuat for the first well-observed facts. He has taken various pipes, at first rectilinear, and measured the head necessary to obtain from them a certain volume of water in a certain time: he has then bent them in different forms, and in such a manner that the central current had a tendency to be reflected at angles of determined number and acuteness, and again examined the head with which they discharged an equal volume of water in an equal time. The difference between the two heads, for the same pipe, at one time rectilinear and at another bent, was evidently the head due to the bends, and consequently the measure of their resistance. The principal of twenty-five experiments, which he has thus made, are given in the following table:—

PIPE.			Velocity per Second.	Resistance due to the Bends.	Coefficient Deduced.
Diameter.	Length.	Angles. Number & Value.			
Inches.	Feet.		Feet.	Feet.	
1·07	10·39	1 of 36°	7·55	·067	·0034
1·07	10·39	2 of 36	7·55	·133	·0034
1·07	10·39	3 of 36	7·55	·221	·0037
1·07	10·39	4 of 24·57	7·55	·133	·0034
1·07	10·39	10 of 36	6·36	·524	·0037
1·07	12·40	4 of 36	5·16	·146	·0039
1·07	12·40	4 of 36	2·60	·036	·0039
1·07	55·46	4 of 36	2·54	·035	·0039
2·13	22·66	4 of 36	7·66	·257	·0030
2·13	22·66	4 of 36	5·22	·118	·0031
2·13	22·66	6 of 24·57 5 of 36 1 of 56·23	7·66	·767	·0038

Dubuat concludes from his experiments, that the resistance arising from bends is proportional to the square of the velocity of the fluid, to the number of angles of reflection, and to the square of their sines.

In this hypothesis the coefficient varies but little, and its mean value is ·0037. So that if v be the velocity; n, n', &c. the number of angles of reflection of equal measure; i, i', &c. the respective measures of the angles, the resistance will be

$$\cdot 0037\, v^2 (n \sin^2 i + n' \sin^2 i' + \ldots\ldots\ldots\ldots);$$

or in function of Q, and taking s for the sum of the squares of all the sines, $\cdot 0061 \frac{Q^2}{D^4} \times s^2$.

18. In the application of this formula to any given conduit, we must determine the number and value of the angles of reflection for each bend. Now, a simple diagram shows, 1st, that in a pipe bent to an arc of a circle (and no other curves need be admitted in practice), half the diameter of the pipe divided by the radius of the arc, will give the versed sine of the angle of reflection, and we may consequently get its cosine and value in degrees; 2ndly, that the number of degrees in the arc (*i. e.* the supplement of the angle of the curve), divided by twice the angle of reflection, will indicate the number of angles.

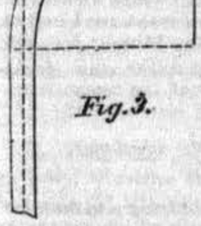


Fig. 3.

Let us, for example, take a conduit pipe, ·82 feet diameter, conveying 1·76 cubic feet of water per second, and which presents a bend of 95°, the radius of the curve being 6·89 feet: what will be the resistance occasioned by this bend?

According to the rule laid down, the versed sine of the angle of reflection will be ·0595 $\left(= \frac{\cdot 41}{6\cdot 89}\right)$, and its cosine ·9405 (=1−·0595), the cosine of an angle of 19° 52′; this is the angle of reflection. The arc of curvature 85° (=180°−95°) divided by 39 73° (twice the angle of reflection), will give their number; this we shall take as 3, the quotient being 2·14. The sine of 19° 52′ is ·3398, and its square ·1155; the resistance sought will therefore be

$$\cdot 00608 \frac{(1\cdot 76)^2}{(\cdot 82)^4} \times 3 \times \cdot 1155 = \cdot 0144 \text{ feet};$$

a quantity extremely small, although the curve was tolerably acute and the velocity considerable. For the pipe with fifteen bends, in Rennie's experiment, the above method of calculation would give a resistance of ·633 feet: the experiment itself, as we shall shortly see, gave 1·16 feet, which would raise the coefficient of Dubuat from ·00608 to ·01113. But such a case as this seldom occurs in practice; nor does the value of the resistance, even if we double the coefficient, often amount to an inch loss of head.

We may neglect account of the value of this resistance in curves of great radius; the angles of reflection, it is true, will be greater, but not so strong; and the sum of the squares of the sines, and consequently the resistance, will be less.

19. If the effect of well curved bends is imperceptible, it is not so with angles, properly so called. An experiment of Venturi shows their influence: this *savan* had three tubes made, 1·25 feet in length, and 1·3 inch diameter; one was rectilinear, the second had a bend of 90° well curved, and the third had an acute angle, also of 90°: under a head of 2·88 feet, they filled a vessel containing 4·84 cubic feet, respectively in 45″, 50″, and 70″. The bad effect of angles is shown still more plainly in the experiments of Rennie: with his pipe 15 feet long, $\frac{1}{2}$-inch diameter, and with a head of 4 feet, he obtained, per minute, a discharge

With the rectilinear pipe	·419 cubic feet.
With the fifteen semicircular bends ..	·370 „
With 1 right angle	·333 „
With 24 right angles	·152 „

so that one angle of 90° reduced the discharge more than 15 considerable bends. This fact alone shows with what care all angles should be avoided in the establishment of conduit pipes.

In seeking the heads which made the three pipes with bends or angles give a discharge (·419 cubic feet) equal to that which was obtained when there was neither angle nor bend, we find them respectively 5·15, 6·33, and 30·52 feet. Deducting 4 feet, there remains for the resistance arising from the bends and angles (17) 1.15, 2·33, and 26·54 feet. From which we conclude that the resistance from a single angle of 90°, was more than double that of fifteen bends; and that of twenty-four angles was only 11·4 times greater than that of a single one. This last result also shows that the resistance of angles and bends is not proportional to their number, as Dubuat had remarked. I had also observed a like want of proportion in my *Experiments on the motion of Air in Conduit Pipes* ('Annales des Mines,' 1828, p. 453).

Resistance arising from Contractions.

20. Contractions, of which we are about to treat, are occasioned by a diminution of the section of the conduit for a very short length.

That we may give an exact idea of the resistance they offer to the motion, let us suppose a conduit in which, perpendicular to its axis, we have placed a diaphragm or thin partition pierced with an orifice. The stream, on arriving at this point, will contract and reduce itself to the size of the aperture, taking a greater velocity in proportion as the section is smaller; and this velocity will always be greater than it would have been in this part of the conduit without the partition. The force necessary to produce the extra velocity, the direction of the motion remaining the same, will evidently be due to the resistance offered by the contraction.

Let B be the diameter of the orifice, m its coefficient for contraction. The velocity through this point requiring to be greater than in the conduit, and following the inverse ratio of the sections, will be then expressed by $\cdot0155\, v^2 \frac{D^4}{m^2 B^4}$. The excesses of force, or loss of head arising from the contraction, will therefore be

$$\cdot0155\, v^2\left(\frac{D^4}{m^2 B^4}-1\right) = \cdot0155\, v^2 D^4\left(\frac{1}{m^2 B^4}-\frac{1}{D^4}\right).$$

In terms of the discharge, this resistance will be expressed by

$$\cdot02519\, Q^2\left(\frac{1}{m^2 B^4}-\frac{1}{D^4}\right).$$

M. Navier, considering that the stream, on passing out of the contraction, immediately resumes the velocity proper to the conduit, instead of the difference between the squares of the two terms, $\frac{1}{mB^2}$ and $\frac{1}{D^2}$, takes the square of their difference, $\left(\frac{1}{mB^2}-\frac{1}{D^2}\right)^2$. But as this opinion is contrary to fact, as the experiments given in the next section will show, we must be careful in adopting a result founded on false premises.

It is but seldom, however, that we shall have to make use of the above formula, for in a conduit pipe there ought not be any sensible contraction: should one accidentally be found, this formula will serve to give us the value of its resistance. It will generally be slight; in some experiments made with sluice valves fixed in the conduits of Toulouse, I found, after diminishing the section of one of them by $\frac{84}{100}$, that the discharge was only reduced $\frac{1}{100}$.

21. If, in the same conduit, below the first contraction there be a second, a third, &c., the resistance from each may be determined by the above formula, and their sum taken.

But, in order that these resistances may be thus added, they must be independent of each other; that is to say, the fluid, after passing through the first contraction, must have recovered the general velocity of the conduit before reaching the second. If it were not so, the fluid stream, after leaving the first contraction, would preserve entirely, or in part, the excess of velocity which it had acquired in order to pass through; and a less effort would be necessary for the second, and less in proportion as the distance between the contractions was smaller.

Eytelwein has made many experiments which fully demonstrate this fact. He took tubes 1·03 inch in diameter, at either end of which was a copper plate pierced with an orifice ·51 inch diameter; their length, or distance between the orifices, being given in the first column of the accompanying table. They were fitted horizontally to a reservoir, and the discharge made by each ascertained; this discharge, as compared with the theoretic discharge, which is represented by unity, is contained in the second column: it goes on gradually diminishing, and consequently indicating the resistance increasing, in proportion as the distance between the two orifices is greater. Eytelwein again fixed in a tube 1·03 inch diameter, four thin plates, each pierced with an orifice of ·256 inch diameter, and at a distance of ·256 inch from each other; the discharge was then ·622. When, however, the plates were placed at the distance of 1·03 feet from each other, the discharge was not more than ·0331.

Distance.	Discharge.
Feet.	
·023	·626
·043	·622
·085	·614
·171	·568
·260	·509
·430	·487
1·030	·481
2·060	·478

22. The observations we have made respecting contractions caused by thin plates pierced with orifices, apply equally to those which would be produced by very short tubes of a diameter smaller than that of the conduit. I cite the 24th Experiment of Venturi. This eminent philosopher, with great judgment, arranged his apparatus to consist of two sorts of tubes alternately; the one B, B, were ·148 feet long, and $\frac{4}{5}$-inch diameter; the other C, C, were 1·9 inches diameter, and their length sometimes ·289 feet, and sometimes ·564 feet. He at first made use of a single tube C; then of two, of three, of four, and lastly of five: he successively applied these various combinations to a reservoir, using a constant

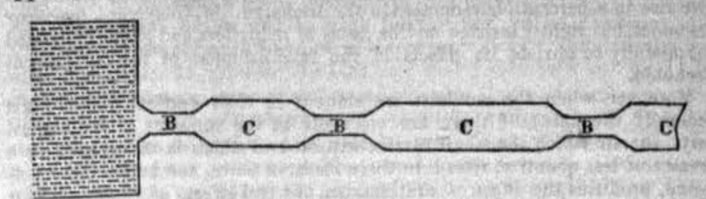


Fig. 4.

head of 2·89 feet, and the following are some of the discharges obtained:—

With a single tube, B	... ...	·0444 cub. feet.
With a tube, C, added	... ...	·0329 „
With three tubes, C	... ...	·0252 „
With five tubes, C ...	... ...	·0202 „

I have attempted to compare these results with those by the methods of calculation I have given: the differences have been sometimes great, sometimes inconsiderable; thus, for the last case I have had ·0185 cubic feet.

23. Notwithstanding the great irregularities which these results present, they are well worthy attention, and principally on account of the very striking manner in which they show the effect produced by enlargements in a pipe; an effect, carried above a certain limit, altogether as prejudicial as that of contractions.

Venturi's entire apparatus, which was 3·2 feet long, may be considered as a pipe $\frac{4}{5}$-inch diameter, having the five enlargements C. It furnished, as we have seen, a discharge of ·0202 cub. feet. He afterwards, with a tube of the same length, but of the uniform diameter of $\frac{4}{5}$-inch, obtained ·0327 cub. feet. The enlargements thus diminishing the discharge in the ratio of 100 to 62.

24. There is yet one other contraction that ought to be considered—that experienced by the fluid stream on its entry into a pipe of less diameter than that which immediately precedes it. The resistance arising from this contraction will evidently be the same as if, at the entry of the pipe, we had placed a plate pierced with an orifice of which the section should be to that of the pipe as m to 1 (m being the coefficient belonging to the contraction); and its expression will then be

$$\cdot02519\, \frac{Q^2}{D^4}\left(\frac{1}{m^2}-1\right);$$

This is a special case of the general formula (20), where B = D.

The value of m can only be approximatively. For a very short pipe, as for cylindrical adjutages, it will be ·82. But in pipes, properly so called, it approaches nearer to 1; and more so in proportion to the length of the pipe, and even, according to M. Prony, as the diameter is greater; so that in large conduits, the effect of this contraction is very small. It is still further reduced by connecting pipes of two diameters by a conical length, gradually diminishing from one to the other.

Lastly, as we have remarked (5), the effect of the contraction at the head of a pipe is implicitly comprised in the values of the coefficients of the fundamental equation; and its effect at the entry of a pipe which branches from a larger conduit, will be comprised in the determination of the head of such branch, so that we need not in any case make calculation of it.

Observations on the Practical application of the Formulæ.

25. The coefficients of the formulæ which we have given, especially those concerning the principal resistance—that due to the friction against the interior of the pipe—have been determined by experiments made chiefly on pipes of small diameter and of no great length (5); they have been generally well-bored pipes, well joined, and free from incrustations. But can such formulæ be safely applied, without modification, to conduits of a different description—namely, to those used in large distributions of water? This is a question which we must now examine.

The pipes of which conduits are formed are almost always more or less imperfect, from the effect of the mould, or in casting; their section is no longer exactly circular, and consequently, *cæteris paribus*, it is smaller than it ought to be. Their interior surface presents inequalities which retard the motion. When joined, the axis of the whole is not always a line without rebatement; the interior is not a perfectly cylindrical surface; the edges of some of the pipes project, and the currents reaching these points, are arrested, divided, and sometimes reflected back again: thus arise eddies in the movement, loss of motive force, and consequently a diminution of the discharge. Even when the pipes are well cast, so that the channel is very

regular, there will be nevertheless, at each joint, a little annular hollow, or a break of continuity, which will produce, to a certain extent, the effect of projections; and which, repeated at every joint in a long conduit, cannot but give rise to a perceptible reduction in the discharge. M. Gueymard, *ingenieur des mines*, has rightly insisted on this cause of reduction, and has endeavoured successfully to obviate its effects in the establishment of the fountains at Grenoble.

Moreover, when the conduits are sinuous in their vertical planes (as is generally the case), if there are no vents at the summits of the highest parts, the air which the water carries with it, and which is disengaged in a greater or less quantity, rises into these elevated parts, and being there collected, produces the effect of contractions, the bad effects of which we have already seen. The cleanest waters, in appearance, always carry with them foreign bodies, and especially extremely fine earthy particles, which are deposited in parts of the pipe; and in time contracting the section, again diminish the discharge. I do not here speak of calcareous and siliceous matter, which, although held in solution in the water, become precipitated on the interior of the pipes, lining them with a stony crust, and, gradually increasing in thickness, would end by stopping them altogether, if not removed in time: this evil is peculiar only to certain localities. It is the same with regard to ferruginous deposits, which are made in a tubercular form in the conduits of Grenoble, and which continually increasing in number and size, diminish the discharge to such a degree that, in eight years, it has been reduced more than one-half. The aërated water, running in pipes, likewise attacks the material, and forms a hydrate of iron, which is deposited in long nipples parallel to the direction of the current, and in greatest quantity on the lower part; underneath these, the iron is as it were corroded, nearly to $\frac{1}{10}$th of an inch. ('Annales des Mines,' 1834, p. 203, *et. seq.*)

Setting aside these local circumstances, it often happens that in experiments made on conduits apparently in a sound state, the discharge has been found to be less by a quarter or a third than that indicated by the formulæ: it is scarcely ever equal to it. I have quoted many of these experiments in my 'History of the Formation of the Fountains at Toulouse.' In consequence of these ascertained facts, the hydraulic engineers of Paris, when making use of the formulæ of discharge, diminish by one-third the value of the numeric coefficients. I have adopted an analogous method, by augmenting by one-half the quantity of water which should determine the size of the conduit. It is, in my opinion, with such latitude that an engineer charged with the establishment of a plan for a large distribution of water, ought to employ the formulæ which we have set forth: he will then avoid the disappointments which would often occur if he uniformly adhered to results given by conduits made with a precision which can seldom belong to his own.

(To be continued.)

ON THE ART OF NAVIGATION.

An Exposition of the Art of Navigation, as applicable to Inland Transit, and of the Works by means of which our Communication with the Ocean is improved and maintained. By David Stevenson, Esq., F.R.S.E.—(Paper read before the Royal Scottish Society of Arts.)

Mr. Stevenson believed he was perfectly safe in affirming, that nothing had occupied a more prominent part in the work of civilising the world than the art of navigation, which had slowly but steadily progressed since the commencement of the 14th century, at which early period the introduction of the mariner's compass opened up a new era in the history of maritime discovery, and gave an entirely new character to commercial enterprise. In its more extended sense, the subject of navigation had, for the last 400 years, formed the grand object on which the labours of Columbus, and of all subsequent explorers of the world, had been expended, while the researches of the philosopher, ths astronomer, the geographer, the mechanician, and the engineer, had all been instrumental in bringing to their present maturity and perfection the various branches of which the vast system of navigation, as it now existed, was made up.

It is not, however, to the subject in that comprehensive sense that he had the honour, at the request of the Council, to direct the attention of the Society. Such an exposition would embrace too wide a field, and lead to the discussion of topics which would not fall within the scope of civil engineering; and he would therefore confine his observations to that branch of navigation which he defined as the department which intervened between the ocean and the land—a connecting link, the true importance of which could be correctly estimated only when viewed in connection with the vast importance of the whole system of which it formed an indispensable part. For how, he asked, could we be benefited by those mighty results of science and of art by which sailing vessels of all classes were now enabled to transport their cargoes from shore to shore with comparative ease and safety, and gigantic steamers to cross the Atlantic with certainty and despatch, did we not extend the beacon light to welcome their approach to our coasts, and provide the means of their withdrawing from the ocean billows into sheltered havens, where their lading might be discharged, and cargoes of our country's produce shipped for foreign lands?—for it must be remembered that it was only when a mariner approached his destined port that the many dangers caused by rocks, shoals, sand-banks, tides, and currents, beset his course; and hence the necessity of employing artificial means to secure that shelter and protection which his vessel required. It would at once occur to the Society that works of various kinds were employed for this purpose: one class of these works consisted in the projection of piers and breakwaters at suitable situations on the coast, so as to form sheltered havens and harbours of refuge; to another department belonged ship canals, by means of which exposed coasting voyages were avoided, and vessels were brought by sheltered and direct routes to their destination; while closely connected with this might be mentioned the system of inland navigation, as effected by the means of canals and the upper compartments of rivers; and last of all, there was that varied class of works by which inlets of the sea, and tidal compartments of rivers, extending from the coast into the country, were opened up and rendered navigable; and he observed in passing, that these various works, connected with the improvement of navigation, formed by far the most extensive and intricate department of hydraulic engineering.

On the subject of harbours formed by the projection of piers and breakwaters, he did not intend to enter at present, and only requested the attention of the Society while he endeavoured to convey an outline of what he conceived to be the extent of our knowledge with reference to the subjects of inland and tidal navigation.

Mr. Stevenson said, that the antiquity of navigable canals—their wide-spread introduction for the transport of goods, and the important place which they had so long occupied in the commercial history of every country—rendered their origin and subsequent progress worthy of attentive investigation; but that only a very brief notice of that class of works could be given. And on that subject he remarked, that from the writings of Herodotus, Aristotle, Pliny, and other ancient historians, we learned that canals existed in Egypt before the Christian era; and at the same early period there was reason to believe that artificial inland navigation also existed in China. Almost nothing, however, save their existence, had been recorded with reference to these very early works; but soon after the commencement of the Christian era, canals were introduced, and gradually extended, throughout Europe, particularly in ancient Greece, Rome, modern Italy, Spain, Russia, Sweden, Holland, and France.[1]

In speaking, however, of the earliest of these works, Mr. Stevenson said that it was not to be supposed that they resembled the present system of inland navigation as practised and known in this country. Early as canal navigation was introduced, it was not until the invention of canal-locks, by which boats could be transferred from one level to another, that the system was rendered generally applicable and useful; and a writer in the *Quarterly Review* remarked, "that to us living in an age of steam-engines and daguerreotypes, it might appear strange that an invention so simple in itself as the canal-lock, and founded on properties of fluids little recondite, should have escaped the acuteness of Egypt, Greece, and Rome."[2] But not only had the invention escaped the notice of the ancients, but the several gradations made towards the attainment of that simple but valuable improvement, appeared to have been so gradual, that, like many discoveries of importance, great doubts existed, not only as to the *person*, but even as to the *nation* by whom canal-locks were first introduced. One class of writers attributed the discovery to the Dutch, and Messrs. Telford and Nimmo, from whose pen the article on Inland Navigation in Brewster's 'Edinburgh Encyclopædia,' was understood to have emanated, adopted the conclusion that locks were used in Holland nearly a century before their application in Italy; while, on the other hand, the invention had been strongly, and not unreasonably claimed by engineers of the modern Italian school, and in particular for Leonardo da Vinci, the celebrated engineer and painter. Without, however, entering into a discussion on this subject, he would simply remark, that during the 14th century the introduction of locks, whether of Dutch or Italian origin, gave a new character to inland navigation, and laid the basis of its rapid and successful extension. And here he said that it might be proper to remark,

[1] Fulton on Canal Navigation. London, 1796.—Vallancey's Treatise on Inland Navigation. Dublin, 1763.—Tatham's Political Economy of Inland Navigation. London, 1799.—Inland Navigation, Brewster's Edinburgh Encyclopædia.

[2] Quarterly Review, No. 146, p. 281.

that the early canals of China and Egypt, although not possessed of locks, were not on that account unadapted to difference of level. It was very doubtful, indeed, if the use of locks had even yet been introduced into China, though intersected by many canals of great extent, the Imperial Canal being nearly 1000 miles in length; and it accordingly appeared that in order to pass boats from one level to another, a rude system of stop-gates and inclined planes had been in use from very early times in that country. Nevertheless the introduction of locks might be held as an important step in the history of inland navigation, and they might be said in Europe and in America to be almost universally used. It was true that inclined planes had been adopted even in this country—in particular on the Shrewsbury and Shropshire canals—and Messrs. Leslie and Bateman had lately recommended this system to the directors of the Forth and Clyde Canal—but the instances of its application were confessedly rare; and, indeed, the only place where he had seen inclined planes extensively used, was at the Morris Canal, in the United States, constructed by Mr. Douglas, of New York, where several planes were in use, having gradients of about one in ten, by which boats weighing, when loaded, about thirty tons, after being *grounded* on a carriage, were raised by water power through a space of fifty perpendicular feet with great success.

But in proceeding to illustrate the progress of inland navigation, he might without tracing its gradual introduction from country to country, remark at once that we found the French at the end of the 17th century, in the reign of Louis the XIV., forming the Languedoc Canal between the Bay of Biscay and the Mediterranean —a gigantic work which was finished in 1681. It was 148 miles in length, and the summit level was 600 feet above the sea, while the works on its line embraced upwards of 100 locks and about 50 aqueducts, the whole forming an undertaking which was a lasting monument to the skill and enterprise of its projectors; and with this work as a model, it did seem strange that Britain should not till nearly a century after its execution, have been engaged in vigorously following this notable example: and this seemed the more extraordinary, as the Romans in early times had executed works in this country which, whatever might have been their original use, whether for the purposes of navigation or drainage, were ultimately, and that even at an early period converted into navigable canals. Of these works he particularly specified the Caer Dike and Foss Dike cuts in Lincolnshire, which were by general consent admitted to have been of Roman origin. The former extended from Peterborough to the river Witham, near the city of Lincoln, a distance of about forty miles: and the latter extended from Lincoln to the river Trent, near Torksey, a distance of eleven miles. The Caer Dike existed now only in name, but the Foss Dike was at this moment an efficient and flourishing navigation: and having been lately professionally engaged in its improvement, Mr. Stevenson stated that he had occasion to inquire somewhat minutely into its past history and condition, and that a very few particulars regarding that, the *oldest* British canal might not be uninteresting.

Among other notices of this early work, Camden, in his *Britannia*, stated that the Foss Dike was a cut originally made by the Romans, and that it was deepened by Henry I., who reigned in the eleventh century, but to what extent it was so deepened did not appear. In 1762 it was reported on by Smeaton and Grundy, who found the navigable depth at that time to be 2 ft. 8 in., and recommended several works for its improvement, which appeared, however, not to have been executed. In 1782, Smeaton was again employed, and deepened the navigation to 3 ft. 6 in.; but it did not appear that its width was increased;[3] and from that period it remained in a very imperfect state till 1840, when the lessee of the navigation employed the firm of which he was a member to design works for assimilating the Foss Dike, both as regarded the breadth and depth of the navigable channel to the rivers Witham and Trent, with which it communicated. When called on to examine the navigation, Mr. Stevenson found its depth to be 3 ft. 10 in., and its breadth in many places was insufficient for the passage of boats, for the convenience of which occasional passing places had been provided; and it was resolved to increase its dimensions and otherwise repair the whole work. Accordingly, the canal was widened to the minimum breadth of 45 feet, and deepened to the extent of 6 feet throughout (alterations which were accomplished without stopping the traffic); the entrance lock was removed, and a pumping engine was erected for supplying water from the river Trent during dry seasons; and that ancient canal, which was quoted by Telford and Nimmo, "as the oldest artificial canal in Britain," was now in a state of perfect efficiency, forming an important connecting link between the Trent and Witham navigations.

Notwithstanding the existence of this early work, however, and of some others in the country, particularly the Sankey Brook navigation, opened in 1760, Mr. Stevenson said that it was generally admitted that the formation of the Bridgewater Canal in Lancashire, the act for which was obtained in 1755, was the commencement of the system of British canal navigation, and that Francis, Duke of Bridgewater, and Brindley, the engineer, who were its projectors, were the first to give a practical impulse to a class of works which now pervaded every corner of the empire, and had been of vast importance in promoting its commercial prosperity.[4]

That the railway system, from the introduction of which we have of late years derived such inestimable advantages, had now, in a very great measure, superseded, and certainly, for the future, must prevent the extension of canals as the means of internal communication, Mr. Stevenson said, was undeniable; and hence at first sight it might appear to some that he was consuming the time of the Society with the details of a subject which, in the present day, might be pronounced to be obsolete. But he reminded the Society, that although this remark might perhaps be considered applicable to such canal works as were intended for the purpose of effecting purely inland communication from town to town, it did not in any degree apply to that more extended class of works called ship canals, which, like the improvement of tidal navigations, were executed for the purpose of enabling sea-borne vessels, by taking an inland course, to avoid the dangers of lengthened coasting voyages—an object of the highest importance to navigation, and which, it was obvious, could not be superseded by the railway system. He presumed, therefore, that he need offer no apology for describing very briefly the characteristics of such canals by reference to works actually executed; and for this purpose he referred to the *Great North Holland Canal*, the largest of the kind in the world. That canal, which extended from Amsterdam to the Helder, a distance of 45 miles, was finished in 1825. It had a cross sectional area, measuring 125 feet in breadth at the surface, 36 feet at the bottom, and no less than 22 feet in depth of water; and what was most worthy of notice, and was, indeed, a characteristic of all the Dutch engineering works, the whole was protected from the German Ocean by embankments, faced with wicker work, the surface of the water in the canal being below the level of the sea. At the time he inspected it the sea was 5 feet higher than the surface of the water in the canal, and the vessels were actually *locking down* from the ocean into the fertile plains of Holland. Its construction was intended to enable vessels trading with Amsterdam to avoid the islands and sandbanks of the dangerous Zuider Zee, the passage through which, in former times, often occupied as many weeks as the transit through the canal now occupied hours. But our own country furnished us with a similar work of great magnitude and boldness; he alluded to the *Caledonian Canal*, which formed an inland navigation composed partly of natural lakes and partly of artificial canal, extending from Inverness to Fort William, a distance of 60 miles, and afforded a depth of 18 feet of water. By means of this inland communication vessels were enabled to avoid the dangers of the Pentland Firth, and also the intricate navigation of the Western Islands: and while the Dutch, in their great canal, had to encounter the difficulties occasioned by the proverbial *lowness* of their country, Telford, in constructing the Caledonian Canal, had to deal with the ruggedness of a succession of Highland glens, and to overcome the summit level of Loch Oich, which was about 100 feet above the level of the sea; and accordingly, in addition to many heavy works which occurred in its course, there was at one point on the Caledonian Canal a succession of eight locks, by means of which a vessel of the largest class of merchantmen could be raised or lowered through a height of 60 perpendicular feet. The locks, which were in close succession, rose one above another, like a series of gigantic steps, and this unique and extensive marine ladder had not inappropriately been termed "Neptune's Staircase."

But without alluding farther to other important ship-canals, he went on to consider the improvement and maintenance of tidal navigations, which formed the sea accesses to the chief ports of this country; and without entering on other arguments in order to prove the importance of that branch of the subject, he had only to remind the Society that the trade of London, Liverpool, Newcastle, Glasgow, Dundee, and by far the greater proportion of the second-class ports, was solely dependent on the maintenance of the tidal

[3] Smeaton's Reports, vol. i. p. 55. London, 1786.

[4] History of Inland Navigation, particulary those of the Duke of Bridgewater. London, 1786.—Hughe's Memoir of Brindley, Weale's Quarterly Papers. London, 1843.

navigations, which, if he might use the expression, formed their only *highways* of communication with the ocean.

In introducing this subject, he would endeavour to explain what was implied in the word "tidal," as used in particular with reference to British ports, as he apprehended there was much more importance to be attached to the term than those who had not studied the subject were aware of; and he believed he would best explain this by drawing a comparison between Britain and some large tract of Continental country, such, for example, as North America. We there found capacious rivers extending for hundreds, he might say thousands, of miles into the interior of the country, and discharging an enormous amount of fresh water into sheltered and deeply indented bays—these indentations in the line of coast bearing, in fact, some proportion to the sizes of the rivers which flowed into them; and such a physical formation afforded facilities of no ordinary kind, not only for the establishment of safe harbours on the sea coast, without the expenditure of capital in their protection, but also for the extension of inland navigation to an almost unlimited degree, by means of the rivers themselves.

To give a practical idea of this, he stated that when he visited America, twelve years ago, he came to the conclusion, after examining the principal harbours on the sea coast which afforded most perfect shelter and a great amount of accommodation, that the formation of the smallest of our Post-Office packet stations in the Irish Channel had consumed a much larger expenditure of capital than the Americans have found it necessary to invest in the formation of harbour accommodation for trading vessels along a line of coast of no less than 4000 miles, extending from the Gulf of St. Lawrence to the Mississippi. With reference to the rivers which discharged into these bays, it was impossible in words to convey an adequate idea, or to describe the feelings which the traveller experienced, when, for instance, after crossing the Alleghany Mountains, and completing a fatiguing land journey from the eastern coast of several hundred miles into the interior of the country, he first came in sight of the river Ohio at Pittsburg. There, in the very heart of the continent of North America, he found a large shipping port, containing a fleet of between thirty or forty steamers, varying from 300 to 700 or 800 tons burthen, moored in the river; and his astonishment was still more increased if he chanced to witness the arrival of one of those steamers, and was told she had come direct from New Orleans in the Gulf of Mexico, and that fifteen days and nights had been occupied in making her *inland voyage* of no less than 2000 miles among the meanderings of the Mississippi and Ohio![5]

But Mr. Stevenson stated that with us the case was altogether different—the isolated and comparatively contracted limits of our country did not afford area for the collection of such bodies of fresh water. In proof of this, he referred to the comparative areas of the basins and the discharges of the different rivers, viz.:—

	Area square miles.	Discharge.
Thames . . .	3,500 . . .	80 220
Tay . . .	2,283 . . .	273,117
Clyde . . .	1,270 . . .	94,000
Mississippi . . .	982,400 . . .	24,600,000

Our streams could therefore, he said, be advantageously navigated only when their waters were deepened by the influx of the tide, and they were consequently closed to all vessels, excepting to those of the smaller classes, during the absence of tidal influence; and therefore our rivers, when compared to those of our Transatlantic or even Continental brethren, could only be regarded as narrow creeks or inlets, kept open by the joint action of the fresh-water stream and the tide; and as the action of the fresh water varied in its extent, and was at best but feeble, that our greatest stronghold in keeping open and deepening our navigations, must be sought for in the action of the tide, which not only scoured and maintained in a navigable state the sea channels of our rivers and estuaries, but also by its presence increased their depth of water. It was likewise, he said, to be noticed, that the fall or inclination of these large continental rivers has been found to be exceedingly small;—for example, the inclination of the Mississippi had been estimated to average, from its source,[6] ... per mile 3 in.

The Amazon	...	...	...	...	5
The Ganges	...	...	...	...	4
While the Thames was		...	...	...	21
The lower part of the Dee			...	...	11
The Lune	...	...	...	...	23
The Forth	...	...	...	...	13

The currents of the larger continental rivers were, therefore, more languid and more easily navigated, whereas the currents of our rivers were more powerful and less easily overcome. But here, again, an important advantage was derived from the tidal influence, which produced an upward current, by which vessels were enabled, without the aid of steam or wind, to reach their port; and he thought that was a view of the subject which could not fail to have struck the most superficial observer, when he saw on any of our navigable rivers or estuaries (such as the Thames or Mersey) a vast fleet of all sizes and from all countries, hurried on by the silent but powerful energy of the flowing tide. What an amount of latent power lay there! And how invaluable was that agency to the commerce of this country! If, indeed, the natural power latent in the *tides* of the Thames and Mersey were suspended, it might truly be said of the *steam* power employed on the net work of railways connected with London and Liverpool, that its occupation would be gone. Whatever, therefore, had for its object the improvement or maintenance of tidal navigations was, he submitted, of vast importance to the commerce, and entitled to the attention of our country.[7]

Mr. Stevenson then proceeded to explain that the chief obstructions to the propagation of the tides were the circuitous routes of rivers—the slopes of their beds—the projection of obstacles into their streams; and that the works by which these obstructions could be best overcome consisted in the deepening, straightening, and widening of the channels—the formation of new cuts—the erection of low rubble walls for the guidance of the currents of the first of flood and the last of ebb tide—the shutting up of subsidiary channels—and the removal of projecting groins. That the more rigidly that class of works was adhered to, the more generally beneficial would be the effect produced; for not only did they improve the part of the navigation where they were executed, but that their tendency was to increase the back water by which the sea channels were kept open. He then proceeded to illustrate these views by referring to the Tay, Forth, Ribble, Lune, and other rivers, where the duration of the tidal influence had been prolonged from 30 minutes to an hour, and the range of tide increased from 2 to 5 feet, while the navigation in all cases had been proportionally improved. Time did not admit of Mr. Stevenson's alluding to many other examples of importance, but the Clyde might be cited as a proof of the length to which such improvements had been carried. In 1755, Smeaton proposed to improve that river by erecting a dam across it with locks in the lower part of the river. In 1775, Golburn surveyed the river, and reported that, as far down as Kilpatrick, there were only 2 feet of water in it, but conceived that the river itself might be improved. In 1831 vessels drawing 13 ft. 6 in. came up to Glasgow, and now large vessels, three or four deep, are to be seen ranged along each side of the harbour. During 1834, 27,000 vessels passed Renfrew ferry, at some periods from 20 to 30 of them in an hour.[8] He next stated that, as an engineer could not form a design for such improvements without accurate data, it was of the highest importance to obtain correct information as to the tides, currents, and discharge of rivers, as well as the nature of their beds, and other particulars, and proceeded to explain how these data were obtained, and showed the different instruments for ascertaining the velocities of surface and under currents, and for procuring specimens of water from different depths; but for details on all these points referred to his treatise on marine surveying.[9]

He further referred to the plans of the Tay, the Ribble, Mersey, Dee, Lune, &c., to show that in each of these rivers there existed a large basin, or estuary, into which the tide flowed, and from which it was discharged twice in twenty-four hours, and stated that it was the flux and reflux of the large volume of tidal water from these natural basins which scoured the seaward channels, kept down the tracts of sand-banks by which their entrances were encumbered, and maintained a navigable depth of water over their bars. The instances to which he referred were all what were termed bar-rivers, or harbours, in contradistinction to such rivers as the Forth or Clyde, which had not similar obstructions. The fact of the existence of a strong tidal under-current was adduced to prove the effect of the flood-tide as a scouring agent, and it was stated, that while the fresh water, being specifically lighter, floated on the surface, the tidal current flowed in a stronger current below. He instanced, in proof of this, various examples, particularly the observations of Professor Traill and Captain Sabine on the Ori-

[5] Stevenson's Sketch of Civil Engineering in North America London, 1838.

[6] Traill's Physical Geography. Edinburgh, 1838.—Johnston's Physical Atlas. Edinburgh, 1849.

[7] Stevenson on the Improvement of Tidal Rivers. London, 1849.

[8] Cleland's Statistical Documents—Transactions of British Association. 1836.

[9] Stevenson on the Application of Marine Surveying and Hydrometry to the practice of Civil Engineering. Edinburgh, 1842.

noco and Amazon[10] (the fresh water from these rivers being traced at a distance of 200 and 300 miles from the land), and also observations by Mr. A. Stevenson on the Cromarty Firth, where the velocity of the under current, at the depth of 50 feet, was ascertained to be at least double the velocity at the surface. The depths of water on the bars of the Mersey and Dee, Mr. Stevenson stated, were only about 11 feet at low water of spring tides—on the Ribble about 7—the Lune about 6—and the Tay about 16; and in navigating such estuaries, vessels must wait for the proper time of tide, either to leave or enter them. It would readily occur, therefore, that the maintenance of the depth of water over the bar was of vital importance to all ports situated within tidal estuaries. From a careful investigation of such localities, he thought it might fairly be stated, that, so long as the capacity of the receiving basins remained entire, no fear need be apprehended of a decrease of water on the bar; and this view he was the more inclined to believe to be correct, from the circumstance that, in several cases where he had occasion to compare the present state of some navigations with their condition as represented in the early charts of Mackenzie, the celebrated marine-surveyor, made upwards of half-a-century ago, he had found, that although the forms of the sand-banks and the direction of the navigable channel might have slightly changed, still there was no appreciable alteration in the depth of water on the bars; while, on the other hand, it had been pretty well established, particularly in the cases of Rye in Sussex, Southwold in Suffolk, and of Chester on the river Dee, and other places, that much injury had been caused by the embanking of land.[11]

The interests of proprietors of land along our rivers and estuaries, were often at variance with those of the conservators of navigation; and the endeavours made in many instances to protect and reclaim land were calculated, from being injudiciously and too extensively carried out, to be highly prejudicial, and hence arose the obvious necessity for some board of appeal between the interests of proprietors and those of the public—a power which was vested in the Lords Commissioners of the Admiralty, to whom, as conservators of navigation, we were indebted for the preservation of many of our harbours and tidal rivers. So important indeed was this subject considered, that, on the motion of Mr. Hume, the government, in 1844, appointed a Tidal Harbour Commission, to inquire into the state and condition of the harbours, shores, and navigable rivers of the United Kingdom, and to report what injury might have been done by encroachments or other interference with tidal waters; and, without detaining the Society longer, he thought he would best illustrate what is generally acknowledged to be the correct theory on this subject, by quoting the conclusion stated in the first report of that commission, which is as follows:—That "as a general, although not a universal principle, no cause has operated more extensively to injure the entrances of harbours throughout the United Kingdom than excluding the tidal waters from lands below the level of high water, which served as natural reservoirs for the flood tide, and were the means of affording a valuable scouring power during the ebb. Nor does any subject more deserve the vigilant attention of your Majesty's Government, or of those entrusted with the conservancy of our harbours, than such encroachments, which are usually made quietly and gradually, and when once completed, are difficult afterwards to remove."

[10] El Maranam y Amazonas. Madrid, 1684.—Sabine's Account of Experiments to determine the figure of the Earth. London, 1825, p. 445.

[11] Reports of Tidal Harbour Commission.—Rennie's Reports on Hydraulics to the British Association.

REGISTER OF NEW PATENTS.

A SALINOMETER.

Andrew Peddie How, of the United States, but now residing in Basinghall-street, city of London, engineer, for "*an instrument or instruments for ascertaining the saltness of water in boilers.*"—Granted July 18, 1849; Enrolled January 18, 1850. [Reported in *Newton's London Journal.*]

The subject of this invention is an instrument called by the patentee a salinometer, by means of which the engineer is enabled to ascertain, at all times and under all circumstances, the density and consequently the saltness of the water in the boilers of marine steam-engines, independently of the pressure within the boiler.

Fig. 1, is a vertical section of the salinometer; and fig. 2, is another vertical section, taken at right angles to fig. 1. *a*, is a small cylinder, having at its lower end a projecting-piece, which is bolted to the side *b*, of the boiler; through this projecting-piece two passages *c*, D, are formed, leading into the pipes c^1, d^1, which terminate respectively at the upper and lower parts of the boiler; and the passages *c*, D, are provided with cocks c^2, D^2. *l*, is an overflow or waste-pipe, for carrying off all excess of water from the cylinder *a*;—*f*, is a cock for discharging all the water from the cylinder *a*, when desired; *g*, is an hydrometer, the graduated stem of which works through a hole in a fixed guide *h*; and *i*, is a thermometer.

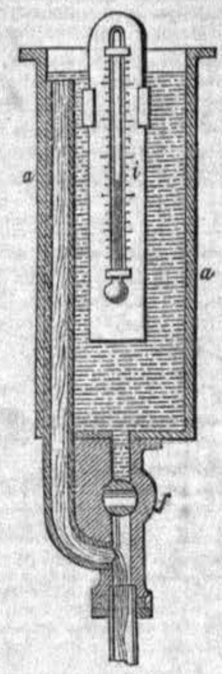


Fig. 1.

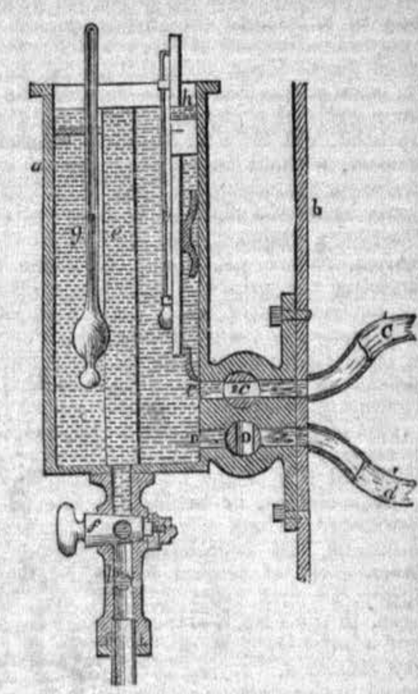


Fig. 2.

The action of the instrument is as follows:—Either the cock c^2, or the cock d^2, is left open (according as it may be desired to test the density of the water at the upper or lower part of the boiler), and the water passes from the boiler through the passage *c*, or D, into the cylinder *a*, and is discharged therefrom through the overflow or waste-pipe *l*; so that there is a constant flow of water through the salinometer of the same density as the water in that part of the boiler from which the supply is derived; and this density is ascertained by examining the graduations on the stem of the hydrometer. If the water, which is passing through the instrument, is derived from the upper part of the boiler, and it is desired to test the density of the water in the lower part thereof, the cock c^2, is to be closed and the cock D^2, opened; then the water from the lower part of the boiler will quickly drive out of the cylinder *a* (through the overflow or discharge-pipe), all the water that had previously entered from the upper part of the boiler; and the water which flows through the cylinder *a*, will then be of the same density as the water in the lower part of the boiler.

A thermometer is combined with the instrument, because the density or saltness of the water varies with the degree of temperature, and it is necessary to correct the indications of the hydrometer by those of the thermometer, as often as the temperature rises or falls beyond the standard point to which the hydrometer may have been graduated. Thus, supposing the hydrometer to have been graduated on the assumption of the water being at a uniform temperature of 200° Fahr., and that $\frac{2^\circ}{32}$ represents the density of the water at that temperature, the patentee finds that for every increase of 10° in the temperature of the water, one-eighth of a degree, or thereabouts, must be deducted from the amount of density indicated by the hydrometer; and for every decrease of 10°, one-eighth of a degree, or thereabouts, must be added. For example, if the temperature is increased to 210°, a deduction of one-eighth must be made on that account, from the $\frac{2^\circ}{32}$, which will bring the density to $\frac{1\frac{7}{8}}{32}$; or if the temperature is lowered to 180°, an addition of two-eighths must be made, which will make the corrected density $\frac{2\frac{1}{4}}{32}$.

The patentee does not strictly confine himself to the above details, so long as the peculiar character of his invention be retained. He makes no claim to the application of either the hydrometer or the thermometer to ascertaining the density or saltness of the water of marine steam-engine boilers; but that which he claims is, the peculiar arrangement, combination, and adaptation of means (each by itself well known) embodied in the single instrument above described, whereby the marine steam engineer is enabled, by the mere inspection of the said instrument, to ascertain, at all times and under all circumstances, the density of the water in the boiler, independently of the pressure within the boiler.

PLANING AND GROOVING MACHINERY.

William Edward Newton, of Chancery-lane, "*for improvements in machinery for planing, tonguing, and grooving boards and planks.*"—Granted October 5, 1849; Enrolled April 5, 1850. [Reported in the *Patent Journal.*]

The planing, tonguing, and grooving of planks or boards, as performed according to this invention, is effected by means of a separate series of tools, acting in a somewhat similar manner to the ordinary hand tools used by carpenters, their construction being also of a like character. These tools are fixed in a framework, while the board or plank to be operated upon is moved up by machinery to the work. The machine, as arranged according to this invention, consists of an endless belt or chain of plates, which form a table for the support and advance of the wood; this chain is formed of a series of narrow plates, linked together, the length of which form the breadth of the chain, and is sufficient to afford room for the greatest width of plank to be operated upon; these are linked together in the manner of an endless chain, and pass over two drums, one situate at the feeding-end of the machine, and the other at or about the middle of its length. The respective parts are supported by two principal side-frames, which carry the bearings of the before-mentioned drums. The axis of the central drum is driven by a train of spur gearing from the driving shaft, which is communicated to the chain by means of recesses in the periphery of the drum, into which the knuckle joints of the chain are received. These drums are placed, with their axes, in a horizontal position; the chain, while traversing the upper portion of its course, forming the table for the support of the wood; the plates of the table during this time rest at each end on the side frame, and are thereby kept in the same horizontal plane. A like endless chain is also provided, which is placed immediately above the other, and at the under line rests on the wood under operation. This chain is, however, considerably shorter than the other, the end-carrying drum of which is immediately over the lower end drum, and the other is disposed at about one-third the length of the frame from that end. The wood to be planed will thus be pressed between the two chains, the under chain however continues the support of the wood beyond the hold of the upper chain, and at which point the planing tools take effect. These tools are fixed to two cheek plates or frames, fitted on the two main wood frames, and form also the immediate support of the chain, as before mentioned. The drum of the upper chain bears in a separate frame, which is free to rise and fall, for the purpose of admitting the different thicknesses of wood to be planed This moveable frame is connected by two links, one on either side of the machine, placed in an inclined position, which, according to their incline, give a greater or less bite on the wood.

The upper chain being also driven, the tendency is to run off the wood, which is prevented by these links. The wood is fed in at the end of the machine, between these two endless chains, and as it emerges below the upper chain, at the opposite end, it passes below the planing cutters, which are a set of eight (more or less) double and single plane irons, similar to the ordinary plane iron, but of the full width of the machine. These planing cutters are set one behind the other, in such manner that each succeeding iron will cut a little deeper than the preceding one, and set at such angles that the rough outside may at one and the same time be operated upon with the smooth or finishing cut. On passing from under the planing tools, the wood is received on a stationary bed, on which it is held down by transverse rollers. The operation of tonguing and grooving then takes effect at the opposite end of the machine, for which purpose the wood, after being planed, is introduced between two sets of ploughing or tonguing irons, one set so as to take effect on either edge of the board The board is at the same time held down, or pressed by edge rollers; one set, together with one set of the cutting tools, are adjustable to suit the width of the board under operation. The rollers are fitted two on each transverse spindle, one roller at either end; the one being fixed, and the other moveable; while the cutters are held in a frame, sliding transversely, and moved by set screws, for that purpose. The cutting tools are similar to those ordinarily used for the purpose by carpenters, and placed at angles to the wood best suited for the purpose. Inclined or bevelled edges may also be prepared in like manner. Instead of the upper endless chain, to feed the machine, a set of weighted rollers may be employed, supported in a swinging frame, connected, as before explained, by the side links, in order to obtain the rise and fall, and to admit the different thicknesses of wood, together with the necessary bite on the wood, for the purpose of feeding it.

The patentee claims: First—The general arrangement of the machinery described.

Secondly—The employment of stationary cutting tools, combined with yielding-bar mouth-pieces, set forth.

Thirdly—Causing the top chain plate, or rollers substituted in lieu thereof, to press on the plank under operation, with a force varying with the resistance opposed by the cutting instruments, by altering the inclination of the connecting side-links described, for the purpose of forcing the plank under operation up to the cutting tools; and

Lastly—The use of adjustable edge rollers, to suit the different widths of wood, in combination with the tonguing and grooving, or other stationary cutters, as described.

IMPROVEMENTS IN VENEERING

Mr. John Meadows, of Princes-street, Coventry-street, has obtained a patent *for improvements in veneering*, which consist in effecting the union of the ordinary veneer in such manner, that it may be applied to irregular surfaces in one piece, instead of joining it at the angles and forming it in several pieces, as usual, which not only gives a great deal of trouble, but requires to be done to a nicety, and when complete, is unsightly, so far as regards the joints being always perceptible; and further, is very liable to get chipped or become detached from the article to which it is applied. In illustration of this mode of applying veneers, a number of ogee mouldings joined with several curved and flat surfaces, meeting at sharp or right angles, are shown in the drawings. A description of one of these will suffice for the whole. The frame or other piece of work to be veneered is prepared of the form required, which, supposing it to be first of an ogee form, the veneer is laid on a bed of that form, placed in a machine somewhat like an ordinary screw press. This bed is hollow, for the purpose of heating it by steam or other medium; pressure is then exerted by the screw on the frame, which is thereby pressed down on the veneer, and into the form required, between the heated bed and the frame or piece of wood to be veneered: so far, the process is very similar to that ordinarily adopted. The next surface presented, or that adjoining the ogee, is a hollow curve, meeting in a right angle the edge of the ogee; the veneer is of sufficient width to cover this, as well as any other portion of the frame service required. On the edge of the ogee bed a hollow bolster is hinged, having a hand lever, by which it is raised, so that the side presented to the veneer, which is of the curved form required, forces the veneer into the hollow, so as to effect complete contact with the whole of that surface; a suitable curved ratchet is provided, which sustains the bolster in its elevated position, the lever being such as to give sufficient pressure for the purpose; the veneer is thus bent over the angle and pressed into the curve. The next is a flat service, united by a right angle to the hollow. Another pad or bolster is hinged by a lever to the bed of the press, which is now raised and sustained by a click taking into a curved rack; the veneer is thereby bent over the succeeding angle, and on to the flat service, when the pad, to give the final pinch, is forced up by a screw; the pressure on the whole of the parts is allowed to remain until the adhesive material is sufficiently set for the purpose. The bolster and pad before mentioned have the levers and screws repeated at intervals, according to the length of the frame or surface to be acted upon. It will be obvious that other arrangements and forms of the parts will be required, according to the particular form to be veneered. Instead of employing ordinary glue for the purposes of veneering, according to this invention, the patentee employs parchment cuttings boiled down and mixed with whiting, to the consistency of paste, which is applied uniformly on the back surface of the veneer, the bed being

at the same time wetted with a brush. The object of employing a white cement is, that the veneer, if thin, is not sufficiently opaque to hide the glue. An extremely thin sheet of brass is interposed between the veneer and the beds, and also a thickness of paper between that and the veneer; the angles are thereby better protected, and rendered sharper. Variations are produced in the forms of the beds, to suit other subjects to be veneered, by the application of paddings or filling pieces, to make up any or all of the parts to the figure required, by which one set of beds may suit a variety of designs of a nearly equal size.—*Patent Journal.*

REVIEWS.

Railway Economy, a Treatise on the New Art of Transport. By DIONYSIUS LARDNER, D.C.L. London: Taylor, Walton, and Maberly, 1850.

Dr. Lardner is commonly so happy in popularising any subject which he takes up, that he is the last man one would think of blaming for writing a book; but here we have book-making with a vengeance. To those who know nothing practically about railways, the book will pass muster; and of those who do, many will be deterred from objecting to it, because they are imposed upon by its appearance of mathematical and statistical labour. The mathematics put us very much in mind of the acquirements of the redoubted Hudibras:

> "For he could tell the time o' the day,
> The clock did strike, by algebra;"

to such a degree is the foppery of symbols carried; and there is a formula for everything. Thus at page 65:

"To determine the average number of miles run by each engine after such cleaning and lighting, it is only necessary to divide the total mileage of the locomotive stock, or of each class of it, by the total number of engines lighted; the quotient will give the distance run by each engine lighted. In general, if E″ express the number of engines lighted, then $\frac{e+e'}{E''}$ will express the average distance run by each engine lighted.

"As examples of the application of this, we take, from the official reports of the Belgian railways, the number of engines lighted during 1846 and 1847. The number was 27,452 for 1846. Dividing this into the total mileage, 2,027,014, already given, the quotient is 73·8, which is therefore the average number of miles run by each engine cleaned and lighted.

"In 1847 the number of engines lighted was 30,676. We have already seen that the total mileage was 2,366,885. Dividing this by the number of engines lighted, we find 77·6 miles as the distance run by each engine lighted, being an improvement on the performance of the previous year."

The practical benefit of this in book-making is, first, the ignorant reader is led to imagine he gets something very good for his money; and, next, by making an algebraic formula—first, for the common operation of division, and by working it out arithmetically afterwards, so much more text is made in an easy manner. The statistics are of the same quality, and of the same value.

Although Dr. Lardner was employed some years ago in mathematical investigations connected with railways, he shows himself very ill-qualified for writing upon railway management. He seems to have stopped so long abroad as to have become Frenchified and un-Englished; and as he is without the practical experience, so he wants the documentary evidence as to railway management. His materials are the English blue-books—worth nothing; the two pamphlets of Captain Huish, the Belgian blue-books, and some French reports; and many French books: and he complains of the want of English statistics, whereas there is a whole body of English railway literature, and, above all, an extensive railway press. All the points Dr. Lardner opens, as he thinks, have been already discussed and settled, so far as they admit of settlement, by many able and practical men; and the railway papers afford invaluable data for the inquiries he has undertaken. The reports of the Committees of Investigation, in particular, afford most valuable information, of which our author has taken no advantage. Our own *Journal* has given information on these subjects to India and the United States; but it does not seem to have been of use to Dr. Lardner. Even the title of Railway Economy has been more successfully used by a Professor Gordon.

Inasmuch as the statistical results of English railway management are more favourable than those of French or Belgian, who are our pupils, it might have suggested itself to Dr. Lardner that our railway administrators are not so much in the dark as he intimates.

While the main body of the work is so unattractive, there is a very interesting chapter on American steam navigation, which, although much of it is trite, nevertheless contains some good matter; but altogether we wish the author had, for his own sake, been otherwise employed.

The title of the book is the best part of it, and that is 'Railway Economy,' which is very much sought after now: but no railway manager can learn anything from the book; nor do we think any shareholder can. Wherever a principle is sought to be established, that principle is limited in its application; and where a discovery is set forth, it is of something already known, and is working or tried, and found inapplicable. The writer has, indeed, missed the whole gist of the subject, or he might, with his popularity as a writer, have taken a very prominent and very useful part in the discussion of railway economy.

The history of railways has been one of progress; and to see it in its true point, and in its future bearing, it must be looked upon as of the same character. All is still new, and all will be innovation. The locomotive begun as a rude engine. Trevithick set it going with one cylinder: Stephenson strengthened it with two. It was still only a beast of burden, when Mr. Booth endowed it with the speed of a race-horse. The contests between the companies have called for an increase of speed; and this has been attained chiefly by an increase of bulk in the engine, and therefore of weight. It must not, however, be assumed that the increase of speed has been attained wholly by increase of weight; for it has been chiefly attained by improved mechanical arrangements, so that an engine of the old prize weight would still have increased speed and power of traction.

With a speed beyond all expectation and all calculation, the whole economy of railways has been altered; and a system has been gradually developed, which, by its development, has pointed out the successful means for superseding it. How we stand now is this: we have heavy engines, heavy rails, and, in continuation, heavy trains, unfrequent trains, great and distant stations, and great establishments.

Originally, it was considered railway traffic would, in its conditions, be like coach traffic—that there would be a succession of coaches, as it were, and station accommodation, was not contemplated. A train arrives, and a large establishment is requisite to attend to it, which establishment is empty-handed until the next train. A passenger comes to a bye country station, and, as he may have to wait some time, station accommodation must be provided for him.

Dr. Lardner's great doctrine is, to get rid of the "empties," and he might have extended it to empty hands; but although railway managers are quite alive to this, they cannot, under the existing system, carry it out; but rather, under the pressure of the times, they are aggravating the present state of affairs by lessening the number of trains—an economy which is attended by an injury to the traffic. The station expenses are now the most untractable items in the budget, and have been a heavy burden, particularly on new branches with a thin traffic.

In virtue of the progress of improvement, light engines and light trains, with a good speed, are now feasible, and we believe nothing stands in their way but the prejudices of the old locomotive manufacturers. We have now long advocated the adoption of the light system; and we are glad to see that its value is now more generally acknowledged, though we do not believe its full operation is adequately appreciated. In truth, the obstinate advocacy of fewer trains, in the teeth of all past experience as to traffic, is a proof of the carelessness even of those who are supporters of the new system. Notwithstanding, this system has now the assent of the whole body of the press devoted to railway polemics, of many engineers, and of many administrators; and, as it is already in practice, so must it go on to success.

While heavy engines were essential, large trains were likewise essential; and as these entailed a heavy permanent way, greater expense in the locomotive department, enormous stations, and large establishments, besides crippling and neutralising the expansion of the traffic by reducing the number of stations and departures, so do light engines allow of light trains, cheap permanent way, economy in the locomotive and carrying departments, a better distribution of plant and staff, cheaper stations, and more of them. By more frequent trains the plant will be closer worked—there will be fewer empties, and the establishment of the electric telegraph allows of a development of traffic which, ten years ago, was impossible.

From stations being now so far from each other, much local traffic is lost, for many a man finds it better to ride or drive, than go some miles to a station, and afterwards have a further journey to make from the arrival station to the place of his destination. We may confidently assert that, throughout, much railway traffic is at present lost, and that railway traffic is still in its infancy. Although there are traffic managers and goods managers, there is not one line which has a statistical department; whereas a competent statician should be engaged by each company to see what traffic there is in the district, how it is carried, what goes on the railway, what does not, and why not. The occasional exertion of a chairman or superintendent of traffic can never keep up with all the minutiæ of the many items constituting the carrying trade; for it is quite as much as such officials can do to attend to the daily working of the traffic under their control, which is their legitimate business.

Nothing but the light-engine system will diminish the margin of waste now constituting the expenditure of railways under the head of way and works, locomotive power, carrying, and stations; and the sooner the able men engaged in railway administration direct their attention to this, the sooner shall we have a diminished expenditure and increased traffic, and be able to do without those impolitic and pernicious expedients of raising fares and limiting the accommodation of travellers. Railway directors, who have generally risen from the ranks, nevertheless forget the circumstances of those classes who are not blessed with a superfluity of wealth. Every tradesman knows better than a railway director, and proceeds upon the principle of getting as much as he can from his customers by suiting his charges to their means in articles of daily necessity. The business of a railway director is to make as large a profit as he can, to carry on as large a trade as he can, and if he has not got trade to make it: but it is seldom he finds this out. The Metropolitan and Dublin Railways without suburban residences, Southampton without packets, Fleetwood without a harbour, the Midland Railway without coal and lime-pits, would fare but badly; and yet, in the teeth of this, how is railway development neglected! The Brighton steamboats have been burked, Sunderland Docks starved, the southern coal traffic kept back, the fish trade left to shift for itself, no attention paid to the carriage of building-stone and lime, and manure generally neglected. Horse traffic flourishes, the canals are in full vigour, and if railways have a large traffic, it is thanks to themselves, and not to their managers, who leave the trade to look after itself.

A Practical Treatise on the Construction of Oblique Bridges, with Spiral and Equilibrated Courses. By Francis Bashforth, M.A., Fellow of St. John's College, Cambridge. London: Bell. 1850.

Although works on oblique bridges are numerous, still one from the pen of Mr. Bashforth is welcome, as that gentleman is well known for his high mathematical attainments. The nature of the work, and the principles on which it is founded, are sufficiently described by the author. He says the methods in his first part are substantially the same as those of Messrs. Nicholson and Buck, but he has introduced numerous variations in the details. He prefers spiral courses for oblique bridges, because although grave objections may be urged, yet the accuracy of form which can be given to the archstones renders it advisable, under proper limitations, to adopt them in preference to a better arrangement of the courses, which does not admit of like exactness in the execution of the work.

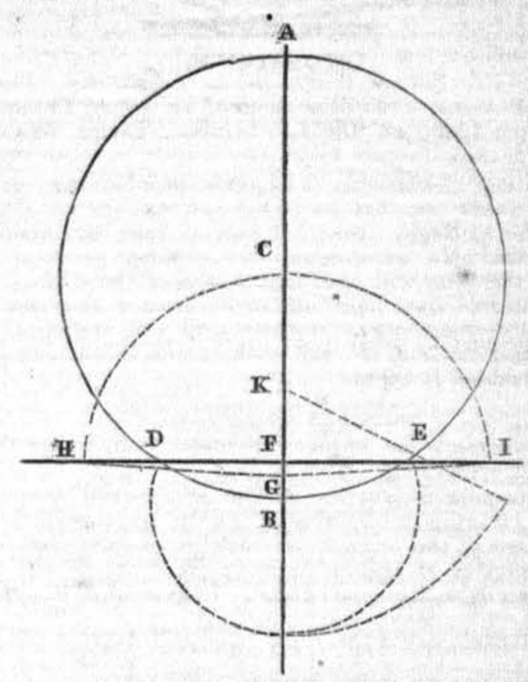
In Part II. Mr. Bashforth has endeavoured to give information on equilibrated courses in oblique arches, suited to the practical man; but we doubt if it be possible or desirable to initiate those concerned in carrying out the details in the elaborate analysis exhibited by the author. Mr. Adie, it will be remembered, was the first to construct oblique bridges of this kind, and Dr. Whewell and Mr. Sang have likewise written upon it.

The work is accompanied by numerous diagrams.

Railways in Ireland.—A return is just printed of all the moneys lent to railway companies in Ireland by the Exchequer Bill Loan Commissioners, and the amounts repaid. It appears that, from 1832 to 1842, the amount advanced to Irish railways was 157.200*l*., and that the interest on such advance has been duly paid. Of the principal, 99,595*l*. has been repaid, and the remainder is in regular course of payment. From 1842 to 1849, there has been advanced to Irish railways, 834.000*l*, chiefly within the last three years. There is no instance in which any arrears of interest are due. Of the principal, 51,179*l*. being the whole amount which has fallen due.

METHOD OF SQUARING A CIRCLE.

Sir—I send, subject to your approbation, the following description of a novel and ready geometrical method of *squaring a circle*, at once easy of application, and more approximate to the truth than any method yet proposed. The resulting square is only in excess of the true area $\frac{1}{65269}$th part; and the side of the square is in excess of the true side only $\frac{1}{130789}$th part; therefore being, for practical purposes, as accurate as the ordinary rule; side of square $=\sqrt{\cdot 7854 \times \text{square of diameter of circle}}$. The process is as follows.



Let ADBE be the given circle. Find DE, the side of a pentagon inscribed in this circle, and produce DE both ways to H and I. Let C be the centre of the circle, and AB be a diameter perpendicular to DE. From F (the intersection of AB, and DE,) set off (on AB) $FG = \frac{CF}{10}$; and with centre G, and radius GC, cut DE produced in H, and I. Then HI is the side of the square GEF.

I have assumed that the side of the pentagon can be readily found, either by angles, or by geometry. In the first case, make the arcs DB, BE, each equal to 36°; in the second case, I have employed a geometrical method which I have not met in any treatise or mathematical work, and which I find very useful. At B erect BL perpendicular and equal to the radius BC. Bisect the radius BC at K; and with centre K, and radius KL, cut AB produced in M; then, with centre B, and radius BM, cut the circle ADBE in D, and E. Join DE, which is the side of the pentagon required.

Demonstration.—Not to enter unnecessarily into a long explanation, it will suffice to state that if the diameter of the given circle be considered $=1$, then $CF = \frac{\sqrt{5}+1}{8}$, and $HI = 0 \cdot 886233701445 \alpha$;

But the true side is $= 0 \cdot 886226925452 \alpha$;

$\therefore$ the resulting side is 6775992 parts in excess in 886226925452; more concisely represented by the fraction, $\frac{1}{130789}$th part.

It may also be shown that the excess of area is nearly double that of the side, for $HI^2 = 0 \cdot 785410196624 \alpha$;

But the true area is $= 0 \cdot 785398163397 \alpha$;

$\therefore$ the resulting area is 12033227 parts in excess in 785398163397; more concisely represented by the fraction, $\frac{1}{65269}$th part.

I think that I have succeeded in showing that this new and simple method is quite as practically accurate as the ordinary numerical rule, with which it also agrees to *four decimal places*. Numerical calculations are always troublesome to working-men, and a good geometrical method of reducing squares and circles has been long desired. As the method I now propose is easier, and more accurate than any previous ones, I shall be happy, through the medium of your *Journal*, to make it known.

J. B. Huntington.

ELLIPTICAL ECCENTRIC COG WHEELS.

SIR—Your Southampton correspondent, "William Davison," is perfectly correct in stating that Elliptical Cog Wheels may be applied with advantage to a variety of purposes, as I have practically proved such to be the case, having made and used them in the year 1840; being considered the first wheels of that shape ever brought under the notice of the public. I patented their application to the working of pump rods: the specification of which, is contained in the February number of the *Repertory of Patent Inventions*, for 1841; published by J. S. Hodson, 112, Fleet-street. But their principle of action is more fully treated on, in a publication that appeared the same year, intituled 'The Principles of Mechanism,' by Robert Willis, M.A., F.R.S., &c., Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge; published by J. W. Parker, West Strand, London. If Mr. Davison takes the trouble of referring to the above work last mentioned, he will find the diagram similar to his own, at page 240.

Ryde, Isle of Wight,
April 19, 1850.

JOHN G. DASHWOOD.

PROGRESS OF THE BIRKENHEAD DOCK WORKS.

THE dock works as viewed from the river seem unfinished and ruinous; but proceed inland to the western end of the Egerton and Morpeth Docks, and a scene of activity bursts upon the view, which it is not easy to parallel. From this point a dam has been carried across to the opposite side of the pool to pen up the waters of the upper portion of the proposed great float; and here, under the spirited contractor, Mr. M'Cormack, twelve hundred men are working night and day, excavating the mud and earth to form a dock which, as at present determined, will extend to the copper works on the Seacombe side of the pool, and give a water area of fifty acres. A further extension, however, is contemplated, which will carry the dock, or float, as far as Poulton bridge; and the contracts for this extension have been advertised for.

The depth of this dock adjoining the quays will be eight feet below the level of the old dock sill of Liverpool, or six feet lower than the bed of any of the docks of our port. The centre will not be excavated quite so deep. A portion of the walling at the Victoria Wharf, which runs at an angle from the dock warehouses, is already completed, and is of excellent and solid workmanship. Another portion, fronting the warehouses, is rapidly advancing. The excavations in the centre of the dock are progressing at a speed which, considering the immense area over which the labour employed is spread, is surprising. Every appliance of mechanical skill, and of steam, is, of course, provided by Mr. M'Cormack in aid of the human labour employed. Two steam engines of thirty horse power each lift the wagons of earth from the bed of the dock to the place of deposit; and more are being provided as the works progress.

The entrance to the float from the Egerton Dock is nearly completed, requiring now only to be smoothed to fit the gates. Those for the inner end of the gut are to be seen in the carpenters' shed adjoining the work, and are of immense strength, and splendid workmanship. They are, moreover, the largest in the world, being 70 feet wide, and show that the Birkenhead Dock Commissioners have had their eyes open to the fact that we may, in all probability, have shortly to accommodate in the Mersey vessels of much larger tonnage and breadth of beam than heretofore. The gate next to the float is to be constructed as a caisson, to be moved altogether, and rest, when open, in a recess made in the dock-wall. The main timbers for this work are also prepared, and are formed of pieces of oak, dovetailed and morticed in, so as to increase their strength, and at the same time prevent deflection.

The gut leading to the tunnel, by which the outer entrance to the dock is to be scoured, is also completed, with the exception of a little smoothing of the sill to ensure the fitting of the sluice-gate. The tunnel is fifty feet wide, and about thirty in height, and through it will pass, when the sluice is opened, a large body of the water in the upper float, which will be refilled to its proper level by the drainage brought down from Bidston marshes. When it is borne in mind that this is spread over the large area of 50 acres, its effect, when compressed, and flowing through an arch of only 50 feet in width, must be to give a most tremendous scouring power.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

INSTITUTION OF CIVIL ENGINEERS.

March 26.—WILLIAM CUBITT, Esq., President, in the Chair.

The first paper read was a "*Description of the Chapple Viaduct, upon the Colchester and Stour Valley Extension of the Eastern Counties Railway.*" By Mr. P. BRUFF, Assoc. Inst. C. E.

This viaduct was thrown across the valley of the Colne, at Chapple; it consisted of thirty-two semicircular arches, each of the span of 30 feet, the total length being 1136 feet, and the extreme height from the foundations to the rail level being 80 feet. The average height of the piers from the foundation to the springing was 45 feet; they were 27 ft. 3 in. wide by 4 ft. $10\frac{1}{2}$ in. thick, at the under side of the impost, and tapered downwards to the plinth, with a batter of 1 in 36; twenty-three of the piers only had plinths, which, consisted of a set-off of $2\frac{1}{4}$ inches, making the dimensions of the base of the piers 29 ft. 6 in. wide, by 7 ft. 1 in. thick. The piers were solid below the plinth, but above that level there was a centre opening 6 feet in width, arched at the top and the bottom. The whole of this viaduct was constructed of bricks made in the district, being chiefly set in mortar, but the arches for a distance of 4 ft. 6 in. above the springing were set in cement. The viaduct occupied about twenty months in construction, and cost about 55*l.* per lineal yard.

The next paper read was "*On the Manufacture of Malleable Iron, with the results of Experiments on the Strength of Railway Axles.* By Mr. G. B. THORNEYCROFT, Assoc. Inst. C E.

It was stated that malleable iron might be divided into two distinct classes, "red short," and "cold short;" the former being generally produced from the rich ores, and the latter from the poorer, or leaner ores. The pig iron made from the rich ores (under the cold blast process only) was not so fluid as that from the lean ores, but when converted into malleable iron it became tough and fibrous, though it was troublesome to work at less than a white heat, which had caused it to be denominated "red short." On the other hand, the pig iron produced from the lean ores possessed greater fluidity, but when malleable it was unfitted to support sudden shocks, or continuous strains, and was hence termed "cold short." It was further stated, that in the manufacture of malleable iron very much depended on the quality of the fuel used in the smelting furnace, and in the subsequent processes; also that iron became crystalline from two causes; first, in consequence of being made from naturally cold short pig iron, and secondly, from a peculiar manipulation during the process of "puddling."

The introduction of hot blast for smelting iron, rendered necessary a careful investigation of the comparative use of hot and cold blast pig iron, in the manufacture of bars, from which it appeared, that if the same quality of materials was used in both cases, equally good bar iron would be produced, though it was more difficult to convert hot blast pig iron into "No. 1" bars, and the waste was greater. It was certain, that whilst good grey pig iron could only be produced, by cold blast, from the best materials, iron of apparently excellent quality could be made, by hot blast, from the most sulphurous ores and fuel; indeed, to this alone must be attributed the bad reputation of hot blast iron, for certain purposes.

As it had been asserted that the peculiar characteristics of malleable iron were to be attributed to the ore from which it was produced, and not from the different nature of the processes used in its conversion, which the author had always believed to be the true cause, he had, at his works near Wolverhampton, made bars of the finest crystalline and of the strongest fibrous texture from the same Yorkshire pig iron. Another cause which induced great changes in the texture of iron, when cold, was compression, or impact, which would completely alter its texture from a fibrous to a crystalline character, as was well exemplified by the "gag" and the puddling tools used by forgemen, and in several parts of different kinds of machinery the same effect was observed.

The author then proceeded to draw attention to the best shape for railway axles, so as to combine the greatest strength with the least material, illustrating his views by the details of a series of experiments made for determining the question. It would appear that railway axles should be made parallel, from journal to journal, without any shoulder, and with just sufficient strength to prevent any vibration in rotating. The experiments showed, that an axle without a shoulder was better able to resist impact than one with a shoulder, in the ratio of 155 to 55, and by leaving the axle parallel, its strength, compared with the same sized axle reduced in the middle, was 5 to $1\frac{1}{2}$.

April 2.—In the renewed discussion upon Mr. Thorneycroft's paper, it appeared to be admitted, that the shoulder on axles was only useful as a gauge, and that it should be curved from, and not square to, the main body;—that between the journals the axle should be parallel, for if reduced in the centre it was sure to bend, and eventually to break. Since the last meeting Mr. Thorneycroft had made many other experiments, which proved his former opinion relative to the progressive changes in iron, from compression, which alone caused the destruction of the fibre, and, in fact, that jarring would not do it. Experiments were suggested to ascertain whether

a pressure on the periphery of a wheel, fixed on an axle and kept rotating, would produce the same results which were admitted to exist in practice.

The paper read was a "*Description of a Lift Bridge, erected over the Grand Surrey Canal, on the line of the Thames Junction Branch of the London, Brighton, and South Coast Railway.*" By Mr. R. J. Hood, M. Inst. C. E.

The act for the construction of this branch, which was a single line, one mile in length, provided that the crossing of the Grand Surrey Canal should be by a swing bridge; but as there were many obstacles in the way of this clause being carried out, and as it was not thought to be the most convenient form of construction, it was determined, after due consideration of the advantages and disadvantages of each particular kind of moveable bridge, to erect one on a principle which might be designated a "lift bridge." This consisted, simply, of a rectangular platform, 23½ feet in width, and 35 feet in length, carrying on one side a line of rails, and on the other side a roadway for carts; it was formed of four beams of oak timber, undertrussed with wrought-iron rods and cast-iron saddles, those for carrying the rails (which were bridge-shaped), being stronger than the others, and having a flooring of 3-inch planking; the platform rested, when down, upon piles driven into a bed of hard gravel, met with at a depth of about 20 feet below the water line. The platform, which was about 12¾ tons in weight, was suspended at the four corners by galvanised wire ropes, four inches in circumference, attached to the end of each oak transome, by means of strong bow springs, and passing over pulleys fixed on four pairs of cast-iron standards, also supported on piles, and fastened at the other end to drums, 3 feet in diameter, each pair of which were keyed on to the same horizontal shaft, situated a few inches under the rail and road level. Upon the same shafts there were also fixed six other drums, of a like diameter with the former, carrying, upon coils of wire rope, 2⅝ inches in circumference, balance weights, of a total weight of 12½ tons, but not equally distributed, intended to assist in raising the platform, and which descended in cast-iron cylinders, or wells. Motion was given to one end of each shaft, by means of simple hand-gearing, consisting of a train of wheels and pinions, by which the power was multiplied twenty-six times.

The level of the rails, above the water-line, was 4½ feet, and as the platform was capable of being raised 9½ feet, sufficient room was afforded for the passage of the barges, the greatest number of which ever passing through in the twenty-four hours being fifteen, and since the erection of the bridge, not one in a hundred had been detained one minute; though on this point, as well as on many others, the Canal Company had raised factious objections, owing to which, and to the design having to be submitted for approval to the Railway Board, great delay arose in the commencement, and also in the execution of the work, augmenting the actual cost to 1,300*l*., which was beyond what, it was presumed, a similar work could, under more favourable circumstances, and when the construction was not novel, be executed for.

The bridge was stated to have proved very successful, and in situations where only a given headway was required for a limited span, this kind of construction was recommended.

April 9.—The paper read was "*On the Construction of Locks and Keys.*" By Mr. J. Chubb, Assoc. Inst. C. E.

The author commenced by stating, that the most ancient lock, of whose form and construction there was any certain knowledge, was the Egyptian, which had been in use for upwards of four thousand years. The construction of this lock was minutely described, also that of the ancient "warded" and "letter" locks, and considerable antiquarian research was displayed in tracing their origin and introduction. These three kinds of locks were, in principle, the foundation of all modern locks, which might be thus enumerated, reversed, for obvious reasons, in their order of antiquity:—

First,—The letter locks; mostly used for padlocks, and were so far convenient, as a key was not required for opening them. A modification of this lock had been proposed, called the "scutcheon" lock, for securing doors and iron safes, but it was too expensive and complicated to come into general use.

Second,—Locks having fixed wards, in which no real improvement had been made in modern times. These locks were bad in principle, as they could be easily picked; and owing to many thousands of them being yearly made, that could be passed by the same key, little or no security was afforded by them; in fact, it might be safely asserted, that twenty skeleton keys would open all the locks, of a given size, made upon this principle.

Third,—The Egyptian lock; the essential principle of which was, that of moveable pins, or studs dropping into, and securing the bolt, all of which must be raised to the proper height, by corresponding pins in the end of the key, before the bolt could be unfastened. This lock was the foundation upon which most of the ingenious inventions of late years had been based, differing only in the forms of the moveable obstructions to the bolt—some of which acted vertically, others horizontally, some with a rotatory motion, and many others in an endless variety of ways; but of all these it was thought sufficient to describe only those best known and appreciated—namely, Barron's, Bramah's, and Chubb's.

In Barron's lock, patented in 1774, a great improvement was made upon the ancient Egyptian, by the introduction of the over-lift, wards being also used; but, from the fact of there being only two tumblers, it was evident that no great change or permutation could be made in the combinations.

In Bramah's lock, patented in the year 1784, there was a compound of both direct and rotatory motion given to the key, instead of simply the latter, as in Barron's lock. It consisted of a number of sliders, having notches of various depths cut on one edge, so that the motion of the bolt was totally prevented, until each slider was pressed down to its exact depth, which was effected by the key having six cuts in it of different lengths.

In Chubb's lock, first patented in 1818, and since modified and improved by various subsequent patents, there were six separate and distinct tumblers, placed over each other, and capable of being elevated to different heights, but all moving on the centre pin. This lock differed from the others, in having a "detector," by which any attempt to pick, or open the lock with a false key, was immediately notified on the next application of its own key.

Calculations were then gone into, to show the number of different combinations which might be made in this lock; and it appeared, that with an average-sized key, having six steps, each capable of being reduced in height twenty times, the number of changes would be 86,400; that if the seventh step, which threw the bolt, was taken into account, the reduction of it only ten times would increase the number to 864,000. Further, that as the drill-pins of the locks, and the pipes of the keys, might be made of three different sizes, the total number of changes would be 2,592,000. In keys of the smallest size, the total number would be 648,000, whilst in those of the largest size it would be increased to 7,776,000 changes.

In conclusion, it was stated, that the manufacture of locks and keys was principally carried on at Wolverhampton and the adjacent towns, Birmingham, and London, and that the fundamental principle upon which all locks should be made, were perfect security—strength, so as to resist attempts to force them, or of opening by picklocks and false keys—simplicity in the arrangement, so that any stranger, having the proper key, might be able to open the lock—and durability.

The paper was illustrated by a series of diagrams, and a variety of specimens of the locks and keys noticed in the paper; and also by a number of Gothic locks and keys of very elaborate workmanship, suitable for ecclesiastical buildings, &c., from Mr. Chubb's works, in London.

In the discussion which ensued many additions were made to the historical part of the subject, and various ingenious contrivances were described, which had been successfully applied, to give increased security to locks of ordinary construction. The combinations in the locks of Summerford, and McKinnon (of New York), were also fully described; an advantage being claimed for the former, in making one tumbler to lift and the other to fall, in order to open it; and, for the latter, that, by the addition of a curtain, of case-hardened iron, three-quarters of an inch in thickness, radiating from the centre of the pin, and a radiating key, there were no means of reaching the tumblers, for the purpose of taking an impression, or otherwise, except by cutting through that curtain. On the other hand, it was positively asserted, that no impression could be taken of, or means invented for picking, a lock which had six tumblers, although it could be easily done with locks having fixed wards; further, that Chubb's lock was a decided improvement on all others of the same character, inasmuch as it possessed a "detector," which formed really the peculiar feature of that lock; the excellence of the workmanship tended also to the facility of action and consequent durability, for which it was so celebrated.

April 16.—The discussion upon Mr. Chubb's paper, "*On the Construction of Locks and Keys,*" was renewed, and extended to such a length as to preclude the reading of any paper.

Several locks which had not been previously mentioned, were exhibited, and their peculiarities of construction were described. These bore the names of their inventors—Davis, Parsons, Williams, and Nettlefold.

It was urged, that the curtain which had been mentioned might be essential for Summerford's lock, but could not be, in any degree, useful in Chubb's lock; in fact, that its only effect would be to induce complication, and augment the cost, without increasing the security.

Among numerous instances of ingenious devices for opening locks, that stated to have been tried in America excited much attention. The process was described to be, that the operator, after inserting two pieces of India rubber, to limit the sphere of action, injected from a force-pump a composition of glue and molasses, in a heated state, which chilled quickly, and, although extremely elastic, had the property of retaining the form and position of the lower side, or bellies of the tumblers, and that after being cut out of the lock, by a thin-bladed instrument, a key could be made from the impression.

In explanation of this, however, it was shown, that in Chubb's lock there existed no similarity between the position of the bellies of the tumblers, when at rest, and the figure of the bit of the key; and, therefore, that even supposing it to be possible to obtain an accurate impression of the position of the bellies of the tumblers, when at rest, no indication would be afforded of the combination, or any assistance be given for making a false key. In further confirmation of this, a lock by Chubb was shown, in which, when at rest, the bellies of the tumblers were perfectly uniform, and in the same plane, so that an impression of the inside of such a lock must be utterly useless for any purpose.

Although it had been asserted that Chubb's locks had been picked, it was admitted that it had never been proved that those locks had really been made by the inventor; but, on the other hand, it had frequently been shown that purious imitations of the first expired patent had been sold in large quan-

tities, and had been marked "Chubb's Patent," until the makers were stopped by legal process, when it was ruled, both at law and equity, that, although after the expiration of a patent, any person might manufacture the article, he had no right to pirate a peculiar trade mark, or to use a distinctive stamp, which was irrespective of any patent right.

The locks used at Pentonville Prison were instanced as uniting goodness and safety with extreme cheapness; but it was admitted that the workmanship was very inferior to that of Chubb's locks.

It was also asserted that Davis's locks, invariably used on the Cabinet Dispatch-boxes, which frequently contained important secret papers, were never found to be out of order, or to be susceptible of being picked.

To this it was replied, that Mr. Chubb was prepared to produce a workman, who, without having ever previously seen the locks on the Cabinet Dispatch-boxes, would open any number, on being allowed half an hour for each; and that the same might be done more easily with the Pentonville Prison locks.

In summing up the discussion, it was stated to be the duty of the Institution to express the conviction, of a veritable Chubb's lock never having been picked either in Great Britain or on the other side of the Atlantic; that it did, in fact, combine that strength, simplicity, and security, without which the most ingenious locks were utterly useless; that it possessed the merit, in the production, of never, through fear of competition, having reduced the quality of the workmanship to meet a reduced price, and thus, by a due consideration of the workmen employed in the manufacture, the men had been taught to be as jealous of their master's reputation for good work as he could be of himself, and that thus the merited reputation of the work had been, and was still, maintained.

April 23.—The paper read was a "*Description of the Insistent Pontoon Bridge, at the Dublin Terminus of the Midland Great Western Railway of Ireland.*" By Mr. R. Mallet M. Inst. C.E.

This bridge was stated to be situated on the line of approach from the city to the terminus, and formed a passage over one branch of the Royal Canal, where it crossed the Phibsborough-road, upon the Foster Aqueduct. By the act it was provided, that the navigation of the canal should be as free and unimpeded as possible; and from the circumstance of there being only a height of 16 inches between the intended surface of the road and that of the water of the canal, it necessarily involved the placing of some kind of moveable bridge, of rather peculiar construction. After due consideration, the one described in the paper was designed and adopted, as being more suitable to the peculiarities of the situation than any other, owing to the water-channel being only 17 ft. 4 in. in width, and that the passage to be made across it required to be at least 50 feet in breadth.

The general idea of this form of moveable bridge was that of a pontoon, or flat-bottomed boat, constructed of iron; the breadth being nearly equal to that of the water space to be crossed, and the length about equal to the width of roadway required. The deck beams of this pontoon projected over the sides, and rested while *in situ*, upon a rabbate, or continuous recess, formed along the top course of each quay-wall, but while the pontoon was floating light, the projecting deck-beams were 2 inches clear of this rabbate, and the roadway platform, constituting the deck of the pontoon, was elevated to an equal height above the level of the top of the quay-walls, or land on each side; in this state the pontoon could be freely and readily pushed along the canal, for a distance of rather more than its own length, until it was brought opposite to a lye-by, provided by increasing the width of the canal at this point, and being put therein, the navigation was perfectly free.

As a pontoon afloat would form a very unstable roadway for carriages, means were provided for allowing it to settle down in the water, and rest firmly upon the rabbates; and also for again raising it rapidly, so as to float clear of the rabbates, and enable it to be moved away into the lye-by. For this purpose two large valves were placed in the bottom of the pontoon, one near each end, by which water was allowed to enter, and sink the pontoon, until it hung upon the projecting deck-beams. For removing this water, when it was required to float the pontoon, a large syphon, of a particular construction, was provided, which was capable of being brought instantly into use, and of being as quickly detached, when a sufficiency of water had been withdrawn to enable the pontoon to be moved. These operations were stated to be performed very readily by one man, the navigation being cleared in four minutes, and the roadway restored in less than three minutes.

The details of the construction of the pontoon, of the syphon, and all other parts of the work were then minutely given; also the total cost of the structure, which, exclusive of the masonry, was 1125*l*., that of the masonry being about 150*l*.; and it was stated to have continued in use, with perfect satisfaction, since its completion in February, 1847.

This form of construction was considered to be applicable in situations where a comparatively narrow water channel had to be crossed by a very wide roadway; but as the particular circumstances of other localities might differ from the one in question, the author suggested various alterations in the details, so as to meet these exigencies.

The next paper read was a "*Description of a wrought-iron Lattice Bridge, constructed over the line of the Rugby and Leamington Railway.*" By Mr. W. T. Doyne, Assoc. Inst. C.E.

This bridge, which was 150 feet span, carried a public road over the Hongham cutting. It consisted of two girders 156 feet in length, and 10 feet 6 inches in depth, placed at a distance of 20 feet apart, and connected together by means of wrought-iron transverse girders, and by a system of horizontal diagonal bracing. The bottom of the main girders were formed of two angle irons, and wrought-iron plates, eight in number at the centre, but diminishing to three at the ends, and of such dimensions as to make the effective sectional area at the centre, after deducting the loss by rivet holes, equal to 26 square inches; that of the top, which was somewhat differently constructed, so as the better to resist compression, being equal to 40 square inches. The lattices were formed of a series of bars of spoke-iron, intersecting each other at an angle of 60°, being crossed at those points, by longitudinal bars, for the purpose of giving additional rigidity, and of making a closer parapet. The transverse girders, 7 feet 6 inches apart, were each formed of a plate of wrought iron, with two angle irons at the top and the bottom; these were covered with corrugated galvanised iron, one-tenth of an inch thick, upon which concrete, and then a layer of gravel and loam metalling, 6 inches thick, were laid. This bridge was erected by Messrs. Smith, Smith, and James, of Leamington, upon a platform which gave to the girders a camber of 7 inches in the centre, which was reduced to $3\frac{3}{4}$ inches upon removing the platform. The total cost of the bridge was about 3,500*l*.

During the progress of the works, the author made some experiments upon the strength of rivets of different sizes, from which it appeared, that the average breaking weight, per square inch of sectional area, was 35·10 tons for a chain joint, and 18·82 tons for a lap joint.

ROYAL SCOTTISH SOCIETY OF ARTS.

The following communications were made:—

Remarks on the Positions laid down by Mr. Cousin, in a Communication lately read by him, "*On the Philosophy of the Beautiful, and an Analysis of the Principle of Proportion, as applicable to Architecture.*" By Mr. Thomas Purdie, Edinburgh.

Mr. Purdie stated the principle on which Mr. Cousin seemed to found his doctrines, viz.—that the mind receives a pleasure from certain proportions, whether in the relations existing between the various parts of a building, or in the relations which the notes of a musical chord bear to each other in the number of vibrations required to produce them. That harmony is, therefore, "the perception of these relations," conveyed to the mind in the one case by the eye, and in the other by the ear.

Mr. Purdie contended that this definition of harmony was only a confounding of names. That the word harmony is applied to architecture only in a conventional or metaphorical sense, and may therefore be used to convey any meaning which fashion or fancy may happen to dictate. But, whatever harmony in architecture may be, the mind which perceives nothing and knows nothing of the relations of musical notes or of vibrations may receive a pleasure from harmony of the most intense and elevated kind. While the secondary beauty of harmony is, doubtless, due to its connection with man's deepest feelings and most interesting emotions, its primary beauty can be attributed only to sensation as an ultimate fact in man's mental constitution, and has no more connection with perception of relation than have the prick of a pin or the perfume of a rose. If there were any beauty at all in ratios, the ratio existing between the diameter and circumference of the circle seemed to possess quite as much of that desirable quality as the ratio of one to two, or three to four. If harmony, he contended, were the perception of relation, and if those relations only were beautiful which are simple and definite, what would have become of the mathematician engaged in the higher calculus where many of the calculations refer to irrational and even imaginary quantities. A single page of it would evolve an amount of discord sufficient to drive altogether mad any mathematical devotee who might happen to be cursed with a musical temperament.

But granting that Mr. Cousin had established the premises—that harmony is the perception of relation, and that beauty results only from the perception of definite relation—he had only placed his doctrines in a position which rendered their complete fallacy the more obvious and apparent.

Take any number of rectangular forms such as those to which it is proposed to apply this system of proportioning—say two windows of a building with the space between them. Adopt some of those ratios which Mr. Cousin asserts to be beautiful, and apply them to the diagonal lines of these rectangles. Let the diagonal line of the windows form with the base an angle of 60 degrees, and that of the space between them $67\frac{1}{2}$. These numbers, if the angles be taken as the standard, bear a simple or harmonic ratio to each other, and to a right angle. But it is impossible to suppose that the relations of angles, formed by unseen diagonal lines, which are supposed to be drawn within certain rectangular figures, can serve as the foundation for a system of proportion, or that they can produce so powerful an effect as the relation between the sides, which are visible to the eye; and, unfortunately for this theory, it happens that the sides must of necessity be at variance with Mr. Cousin's proportions in every case, when the angles are in accordance with them.

In the designs exhibited to the Society, Mr. Cousin, for the most part, adopted the angles as the basis of his harmony; but he sometimes admitted the proportion of the sides, and at other times he admitted of both in the

same elevation. Granting, then, his definition of harmony to be correct, no building could possibly be beautiful; for the eye, which was gratified by the simple ratio existing between the angles, must also perceive and be offended by the want of these so-called harmonic proportions in the sides.

Mr. Purdie farther objected to this theory on the broad ground that it involved the setting aside of taste altogether; that it was calculated to erect within the dominion of taste a tribunal to overrule and supersede its judgments. If any one were to object to a building of Mr. Cousin's, or of any other architect, designed on the principles brought before the Society as being ill-proportioned, it could be no answer to tell him that this was an angle of thirty degrees, that of forty-five, and so on. Unless the jurisdiction of this theory were to be supreme, the architectural critic would have a full title to hold to his opinion, notwithstanding these so-called mathematical demonstrations. But as the explanations which the discussion on Mr. Cousin's paper called forth, at a late meeting of the Society, had placed the matter on a very narrow ground, Mr. P. preferred to leave it there, rather than enter upon matters which could only lead to endless and perhaps altogether unprofitable discussion.

Observations on what is required to be done, in order to improve the Dwellings of the Working-Classes; with a brief notice of some Model Houses recently erected in this neighbourhood, and some account of those which have been built in London, Glasgow, &c. By Patrick Wilson, Esq., Architect.

Mr. Wilson observed, that in looking at the large tenements in the centre of Edinburgh, occupied by a prodigious number of families, some of them elevated six or eight stories from the street, it must appear almost an impossibility for such families to have anything like cleanly dwellings; the common stair of such tenements is, in general, in such a state of filth, that there is no inducement to the housewife of cleanly habits to attempt keeping a clean house. He, therefore, contended the working-classes must be placed in self-contained houses. Such an idea might at first sight appear Utopian, but so far from this being the case, it had actually been realised, and that at a rent not exceeding what is paid for the same accommodation in other situations.

Mr. Wilson then took a rapid glance at what had been doing in other towns. He gave some brief account of the houses recently erected in London; but in general remarked that they could not be taken as a guide for us in Edinburgh, the rents paid for them being far beyond what could be afforded by Edinburgh operatives.

Mr. Wilson laid before the Society the plan which had occured to himself sometime ago for improving the dwellings in question, which he had since had opportunity of carrying into practice. To effect this on the most economical plan, he proposed having houses of two stories high, the houses on the first floor to have their entrances on the one side, and those on the second floor on the other side; and further, that rows of such houses should be placed at *right angles* to the road or street.

There are six rows of houses, each row containing eight houses, four on the ground-floor and four on the second floor. The spaces of ground between the rows are devoted for bleaching-greens, with the exception of a footpath on each side leading to the houses. The Model houses recently erected at Industry-lane, North Leith, under the superintendence of Mr. Wilson, are built on this plan. The piece of ground at Industry-lane only admitted of two rows: one is built, and the houses are at present being finished, the other is in contemplation to be built. The houses are of various sizes. The average size contain, one large living room or kitchen, one bed-room, a scullery sufficiently large for the mistress of the family washing in, well lighted, and furnished with sink and water-pipe, and a pantry. The sculleries are placed two and two together, not only so, but those on the lower floor being immediately under those on the upper floor; there are four sculleries all in a cluster, which arrangements, besides the economy, possessed other advantages which Mr. W. pointed out. With the exception of the water-closet, each house possesses every convenience within itself. The water-closets are placed out of view at the farther end of the row, and under lock and key. The apparatus for these closets are of the most simple construction; one cistern supplies the whole cluster with water.

The largest size of houses at Industry-lane contains a large kitchen, two bed-rooms, and the other conveniences already described. These were commodious houses, and what in Mr. Wilson's opinion, every house should be, provided those for whom they are intended could pay a proportionate rent. The parents and younger branches would be accommodated in the large apartment, the boys in one room, and the girls in the other.

The houses at Industry-lane are all let at the following rents:—Two houses at 5*l.* 5*s*; two houses at 6*l.* 6*s.*; two houses, each with two bedrooms, at 7*l.* 15*s.* Total receipt, 51*l.* 4*s.* Cost of the eight houses, 700*l.*, 5 per cent on which is 35*l.*; feu-duty, or ground-rent, 3*l.* 5*s.* 6*d.*; making a total outlay of 38*l.* 5*s.* 6*d.*; and leaving for taxes, repairs, &c., a margin of 12*l.* 18*s.* 6*d.*

A considerable portion of ground has been feued at a very moderate rate, through the kindness of Mr. Balfour, of Pilrig, and on which it is intended to erect houses somewhat similar to those at Leith.

Description and Drawings of a new Patent Air-Spring for Shutting Doors and Gates, opening one or both ways: with a narrative of the Patentee's Experiments in arriving at the best arrangement. By Mr. George Beattie.

Mr. Beattie stated that in this new Patent Spring Hinge the pressure of the atmosphere is employed for the motive power to close the door. That it is not a spring properly so called, but simply a counterbalance, by means of the pressure of the atmosphere made to act towards a vacuum, the resistance being uniform throughout the travel of the door, which combines comfort, safety, and durability. The air spring consists of an iron box and cover let into the floor, which contains a verticle axle supported at bottom in a hollow cup, and furnished at the top end, which projects above the floor, with a shoulder and lever hinge for carrying the door on this shaft, and within the box is fastened a horizontal wheel, which is toothed upon a portion of its circumference. On each side of this wheel is a rack attached to a piston, which is made to fit tightly into a cylinder by a cap leather. In the under side of the cylinder is a valve communicating with the outside; in the bottom of the cylinder is another valve communicating with an exhausted chamber, and on each side of the racks are guides for the piston. The teeth of the wheel are made to take in either of the toothed racks, according as the door or gate is opened one way or other, so that the piston will be drawn along the cylinder, leaving a vacuum behind, at a uniform and regular degree of resistance, until the door is released, when the unbalanced pressure of air upon the face of the piston will cause the door to resume its original position. The use of the valve communicating with the outside of the cylinder is that, in case of a leakage of air behind the piston, it shall be driven by the return of the piston through it to the outside. The use of the exhausted chamber and valve communicating with it is, that a portion of the leakage air or oil which cannot be discharged by the valve leading outwards, escapes into the exhausted chamber, which allows the piston to get to the bottom, and to bring the teeth of the rack in hard contact with the teeth of the wheel, and thereby keep the door steady and in its proper place when shut. The box requires to be filled with lard or sperm oil to seal the piston, and keep the whole lubricated.

Description of an Improved Method of Constructing Wire Fences. By Mr. James Smith.

It was stated that the object of this plan is to increase the simplicity and facility of the construction of wire fences, and to afford easy means of correcting the occasional defects of over tightness or over slackness of the wire lines, whether arising from faults in the construction, or from the vicissitudes of temperature: that this is effected by mounting the straining posts with rollers and ratchet wheels for the wires, by which, with tools of the most simple kind, an ordinary labourer can erect the fence and stretch the wires in the most perfect manner; and the wires, when becoming too slack or too tight, can be easily corrected, so as to keep them always in a perfect state: and that the expense of obtaining these advantages very little exceeds that of constructing the fence on the common method.

NOTES OF THE MONTH.

Important Application of Hydraulic Pressure.—A powerful hydraulic engine has been placed at Murton colliery, belonging to the South Hetton Company, by Messrs. Armstrong and Co., for the purpose of drawing the trains of waggons underground without the aid of a steam-engine (so dangerous in such a situation), or of horses, where a large number would not be so efficient as this new machine. The engine consists of four small cylinders and pistons, each being three inches in diameter, with a 12-in-stroke; the water which supplies the power is that pumped from the shaft, collected in a reservoir 606 feet above the level of the water engine, and, of course, applying an enormous force to the pistons; the pipes conveying the water down the shaft are 4½ inches in diameter; the distance from the shaft from whence the trains are propelled is 880 yards, with gradients from 1 in 30 to 1 in 18; the number of tubs in each train is at present 20 or 21; the time travelling the distance is 4½ to 6 minutes, or 6 miles an hour; the quantity of water pressing on the pistons is 1,500 gallons, and the average speed is 100 strokes per minute, although 130 have been obtained without any jarring motion; the power of the engine is about 30 horses, and the reservoir and column of water collects as much as will draw 20 trains per day; but although it is contemplated to increase that number to 50, that extra number will only involve the pumping of an additional 30 gallons per minute through the 24 hours.

New Brick-Making Machine.—Mr. Hart, engineer, of Seymour-place, Bryanstone-square, is now exhibiting a machine for making bricks, which, besides producing them with greater rapidity than by any previous machine, and at a less cost, possesses the advantage of turning them out in an exceedingly dense and homogeneous form, requiring no great length of time after pressure before they are fit for the kiln. The machine is very powerful, but compact. The clay is placed in a hopper, in a rough state, from whence it passes, in a well-kneaded condition, into the brick moulds, which are placed upon an endless chain; here it passes beneath the presser, which reduces the bricks to the proper size, and after this part of the process they are stacked for drying. It is stated that one horse, two men, and four boys, at a cost of about 1*l.*, can turn out 26,000 perfect bricks, stacked, in 12 hours. The machine is also admirably adapted for pressing into cakes oil dregs, and other similar substances.

Establishment of a Meteorological Society.—A meeting of gentlemen devoted to astronomical and meteorological pursuits was held at the baronial and hospitable seat of Dr. Lee, of Hartwell, near Aylesbury, last month, which led, during three days discussion, to a good deal of interesting detail on various matters connected with science, and ended in the formation of the British Meteorological Society, to which Mr. Glaisher, the accomplished observer and superintendent of the Meteorological Department at Greenwich, consented to become secretary; S. C. Whitbread, Esq., F.R.A.S., was nominated president; Dr. Lee, LL.D., F.R.S., treasurer; and a Council of several other gentlemen, most of whom are members of the Astronomical Society, was formed. It was arranged that a meeting of the officers should take place on the 7th of May, and that gentlemen desirous of promoting the science might be admitted members on signifying their wishes to Mr. Glaisher, of Blackheath, before that day, after which members will be admitted by ballot. Meteorological Reports are already made from forty different stations in the kingdom, and arranged, condensed, and printed in the Quarterly Report of the Registrar-General, by Mr. Glaisher. It is desirable to increase the number of the stations, and that accurate and regular observations of standard barometers, thermometers, and hygrometers, should be multiplied, with a view to establish some general principles of atmospheric variation, in relation to storms, weather, and diseases. Among the subjects discussed at the meeting was that of meteoric stones, one of which, in the possession of Dr. Lee, had fallen at Launton, Oxon, in 1830, and which had been examined, and recorded in 'Loudon's Magazine of Natural History,' by Mr. Stowe, of Buckingham, in March, 1831. Mr. Glaisher had received accounts of the descent of the late meteor from many observers, who estimated its altitude and course, from the Bristol Channel across Wales, and immediately over Northampton, till it burst at the height of 20 miles over Biggleswade, where fragments have been sought for, but at present without success, though its bulk must have been enormous. The interval which occurred between the appearance of the light and the noise of the explosion was measured accurately by the Rev. Joseph Read, of Stone, near Aylesbury, who had a chronometer in his hand at the moment, and was found to be 53 seconds; and another gentleman, 15 miles south of Stone, estimated it at 57 seconds. Dr. Lee had sent a model of his Aerolite to the Museum at the India House, and the curator, in return, sent him a model of one that fell in India, which, though of larger dimensions, had very much the shape and character of the Oxfordshire stone, which weighed, at its descent, 2 lbs. 5 oz.

South Wales Railway.—A wrought-iron bridge of very large dimensions is now in course of construction by the extensive ironfounders, Messrs. Finch and Willey, of Windsor Foundry, Liverpool, who have erected substantial temporary premises for the purpose. The bridge has been designed by Mr. Brunel, the civil engineer of the line, and is to be thrown across the river Wye. Its extreme length will be 600 feet, there being four arches or spans, one of 300 feet, and three of 100 feet each. As the navigation of the river cannot be interfered with, the immense span of 300 feet is rendered necessary, in order to prevent the erection of piers or other works, as a foundation on which to rest the mass of iron-work which will be brought into requisition. The principle adopted is that of suspension from a tube by diagonal chains, which carry the girders on which the line of rails is laid, and besides many other improvements being introduced to adapt the bridge to the peculiarities of the situation in which it will be required. The contraction and expansion of the iron-work is provided for with the greatest exactness; oscillation and undulation from any of those causes by which they are usually produced on railway bridges will be effectually prevented. The roadway will be nearly 150 feet above the level of low-water mark. Large cylindrical pillars are to be driven into the ground near the margin of the river, and from these and the piers, which form the extreme points of suspension, the main support for the structure will be derived. The iron likely to be used in the bridge and cylindrical pillars will amount to 2,000 tons. To expedite the work, a large and very powerful engine has been erected, and extensive machinery brought into working order.

Metropolitan Commission of Sewers.—An account of the receipt and expenditure of the Metropolitan Commission of Sewers for 1849 has just been published. The receipts amounted to 71,623*l*. 18s. 10d., the items composing this total being 55,105*l*. 3s. from rates, 13,518*l*. 10s. 10d. from contributions, &c., and 3,000*l*. from loans. The payments were as follow:—For works, 50,309*l*. 4s. 1d.; surveys, &c., 8,339*l*. 19s. 10d.; management, 22,400*l*. 17s. 5d.; loans, 4,014*l*. 12s. 8d.; contingencies, 280*l*. 9s. 6d.; making a total of 85,345*l*. 3s. 6d. The cash in hand at the commencement of the year 1849 was 22,956*l*. 3s. 7d.; at the end of the year it was 9,234*l*. 13s 11d. The total amount paid for contracts commenced and completed for general works during the year was 40,606. 5s. 4d., being 10,573*l*. 11s. 5d. for sewers, 5,577*l*. 9s. 6d. for openings (side entrances, air shafts, gullies, private drains and flaps), 3,956*l*. 11s. 5d. for repairs to sewers, gullies, &c., 18,595*l*. 18s. 10d., for cleansing, including, flushing, casting, and lifting, 1,460*l*, 2s. 9d. for incidental works, and 452*l*. 11s. 6d. for paving and gravelling relaid. An additional sum of 2,318*l*. 14s. 11d. was expended under contracts for special works, being 100*l*. for incidental works, and 2,218*l*. 14s. 11d. for sewers. The total amount of monies owing to the Commissioners on account of uncollected rates is 56,171*l*. 12s. 11d. The debts owing by the Commissioners amount to 100,738*l*. 1s. 1d., viz. 65,787*l*. for loans, 465*l*. 14s. for special contracts, and 34,485*l*. 7s. 1d. for tradesmen's bills and other obligations not under special contracts.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM MARCH 20, TO APRIL 23, 1850.

Six Months allowed for Enrolment, unless otherwise expressed.

William Joseph Curtis, of Port of Spain, Trinidad, West Indies, civil engineer, for improved machinery and apparatus adapted for the manufacture of sugar.—March 23.

Horatio Carter, of Thirza-place, Old Kent-road, Surrey, gentleman, for certain improvements in the production of light from ordinary coal gas, by the use of burners, consisting of more than one ring or sheet of flame, combined with a suitable chimney or chimneys, and supplied with atmospheric air, particularly adapted to ventilation.—March 23.

Joshua Siddeley, jun., brassfounder, of Liverpool, for certain improvements in ships' fittings.—March 23.

Alfred Wilson, of Myddleton-street, Clerkenwell, clock-case maker, for an improved ventilator.—March 23.

John Stephenson, of Roan mills, Dungannon, Tyrone, flax spinner, for certain improvements in machinery for spinning flax and other substances.—March 23.

William Sykes, of York-street, Middlesex, tallow chandler, for certain improvements in the manufacture of candles and wicks.—March 23.

John Varley and Joseph Hacking, of Bury, Lancaster, engineers, for certain improvements in steam-engines and apparatus connected therewith.—March 23.

Henry Robert Ramsbotham, of Bradford, Yorkshire, manufacturer, and William Brown, of the same place, mechanic, for improvements in preparing and combing wool.—March 23.

John Gedge, of Wellington-street, Strand, Middlesex, for an improvement in lamps and candlesticks. (A communication.)—March 23.

Nathaniel Matthew, of Wern Tremadoc, Carnarvon, quarry proprietor, for an apparatus for cutting or dressing slates into various shapes and sizes.—March 23.

Alfred Guillaume, Roseleur, of Paris, France, but now of 4, South-street, Finsbury, Middlesex, chemist, for certain improvements in coating or covering metals with tin.—March 23.

Alfred Vincent Newton, of the Office for Patents, 66, Chancery-lane, Middlesex, mechanical draughtsman, for improvements in the preparation of materials for the production of a composition or compositions applicable to the manufacture of buttons, knife and razor-handles, ink-stands, door-knobs, and other articles where hardness, strength, and durability are required. (A communication.)—March 23.

Edward Welch, of St. John's Wood, London, architect, for improvements in fire-places and flues, and in apparatus connected therewith.—March 23.

Evan Leigh, of Miles Platting, near Manchester, Lancaster, cotton-spinner, for his invention of certain improvements in machinery or apparatus for preparing and spinning cotton and other fibrous substances.—March 26.

Joseph Theodore Clenchard, of Paris, France, manufacturing chemist, for certain improvements in the application of archil to the process of dyeing and printing in colours, and also an improved apparatus to be employed in the operation of dyeing.—March 26.

James Preece, of Hereford, shoemaker, for certain improvements in mills and machinery applicable to the thrashing and grinding of corn, the manufacture of cider, and other similar purposes.—March 26.

Alfred Vincent Newton, of the Office for Patents, 66, Chancery-lane, Middlesex, mechanical draughtsman, for improvements in coupling-joints for pipes. (A communication.)—March 26.

Thomas Dickason Rotch, of Drumlamford-house, Ayr, North Britain, Esq., for improvements in separating various matters usually found combined in certain saccharine, saline, and ligneous substances. (A communicatian.)—March 26.

Thomas Walker, of Wednesbury, Stafford, iron-master, for improvements in the manufacture of sheets or plates of iron for certain purposes.—March 28.

James Samuel, of Willoughby-house, Middlesex, civil engineer, for certain improvements in the construction of railways and steam-engines, and in steam-engine machinery.—April 5.

Joseph Findlay, of Paisley, Renfrew, North Britain, manufacturer, for an improvement or improvements in machinery or apparatus for turning, cutting, shaping, or reducing wood or other substances.—April 5.

George Henry Phipps, of Park-road, Stockwell, Surrey, engineer, for improvements in propelling vessels.—April 5.

Jonathan Charles Goodall, of Great College-street, Camden Town, Middlesex, card-maker, for improvements in machinery for cutting paper.—April 5.

Charles Seeley, of Heighington, Lincoln, merchant, for improvements in grinding wheat and other grain.—April 5.

John Platt, of Oldham, Lancaster, engineer, for certain improvements in machinery or apparatus for spinning, doubling, and weaving cotton, flax, and other fibrous substances.—April 11.

Richard Prosser, of Birmingham, civil engineer, for certain improvements in machinery and apparatus for manufacturing metal tubes, which improvements in machinery are in part applicable for other purposes where pressure is required; also for improvements in the mode of applying metal tubes in steam boilers, or other vessels requiring metal to be applied within them.—April 11.

Amedée Francis Redmond, of Birmingham, for improvements in the manufacture of envelopes.—April 15.

Edme Augustus Chameroy, of Paris, for improvements in the manufacture of boilers and of pipes of mallable substances, as well as of elastic matter.—April 15.

Robert Reid, of Glasgow, manufacturer, for certain improvements in propelling.—April 15.

Cuthbert Dinsdale, of Newcastle-upon-Tyne, dentist, for improvements in the manufacture of artificial palates and gums, and in the mode of setting or fixing natural and artificial teeth.—April 15.

John Turner, of Birmingham, engineer, and Joseph Hardwick, of the same place, for a certain improvement or certain improvements in the construction and setting of steam boilers.—April 15.

George Attwood, of Birmingham, copper roller manufacturer, for a new or improved method of making tubing of copper or alloys of copper.—April 15.

Charles de Bergue, of Arthur-street, London, engineer, for certain improvements in locomotive and other steam engines, also in buffers for railway purposes.—April 15.

John Dove Harris, of Leicester, manufacturer, for improvements in the manufacture of looped fabrics.—April 18.

William Buckwell, of the Artificial Granite Works, Battersea, civil engineer, and George Fisher, of the Taffvall Railway, Cardiff, civil engineer, for improvements in the construction and means of applying carriage and certain other springs.—April 18.

William Henry Ashurst, of the Old Jewry, gentleman, for improvements in the manufacturing of varnishes.—April 18.

Thomas Ross, of Coleman-street, London, gentleman, for improvements in machinery for raising a pile upon woven and felted fabrics.—April 18.

Abraham Moses Marbe, of Birmingham, chemist, for an improved manufacture of vegetable fluid to be used in the production of artificial light, and in lamps or burners for consuming the same; which vegetable fluid is also applicable to the manufacture of lacker or varnish.—April 18.

William Hargreaves the younger of Bradford, York, iron founder, for certain improvements in the means of consuming smoke, parts of which improvements are also applicable to the generating of steam.—April 18.

Peter Arkell, of Chapel-street, Stockwell, Surrey, engineer, for improvements in the manufacture of candle wicks.—April 20.

Alfred George Anderson, of Great Suffolk-street, Southwark, Surrey, soap manufacturer, for improvements in the treatment of a substance produced in soap-making, and its application to useful purposes.—April 20.

John Timothy Chapman, of Wapping, Middlesex, for improvmeents in apparatus for setting up ships' rigging and raising weights.—April 20.

Richard Archibald Brooman, of the firm of J. C. Robertson and Co., of Fleet-street, London, patent agents, for improvements in the manufacture of zinc, and in the apparatus employed therein.—April 20.

Henry Ritchie, of Brixton, Surrey, for improvements in the manufacture of copper, brass, and other tubes or pipes.—April 23.

William Macalpine, of Spring-vale, Hammersmith, general dresser, and Thomas Macalpine, of the same place, manager, for improvements in machinery for washing cotton, linen, and other fabrics.—April 23.

Charles Humfrey, of Downing College, Cambridge, M.A., for improvements in the manufacture of candles and oils, and in treating fatty and oily matters, and in the application of certain products of fatty and oily matters.—April 23.

Antoine Pauwels, of Paris, France, merchant, and Vincent Dubochet, also of Paris, France, merchant, for certain improvements in the production of coke, and of gas for illuminating, and also in regulating the circulation of such gas.—April 23.

Richard Laming, of the New Chemical Works, Isle of Dogs, Middlesex, chemist, and Frederick John Evans, of the Horseferry-road, Westminster, gas engineer, for improvements in the manufacture of gas for illumination, and other purposes to which coal gas is applicable, in preparing materials to be employed in such manufacture, and in apparatus for manufacturing and using gas; also improvements in treating certain products resulting from the distillation of coal, parts of which above-mentioned improvements are applicable to other similar purposes.—April 23.

Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in casting type. (A communication.)—April 23.

Pierre Armand Lecomte de Fontainemoreau, of South-street, Finsbury, for certain improvements in the manufacture of wafers, and in the machinery or apparatus connected therewith. (A communication.)—April 23.

Olympus to take part in their conflicts, or to contest the privilege of presiding over the rising states and cities of their favoured land. The return of the Heraclidæ, and the founding of the kingdom of Lacedæmon, took place about 1104 B.C. Before this, colonies had settled in Ætolia, and the Bœotian Thebes was a flourishing city. In 1044, fresh colonies went out to Ionia; and a band of Greeks had established themselves on the southern shore of Italy, the germ of Magna Græcia. Apollonia, and other cities

support the roof, filling-in the intervals with intertwining branches made weather-proof with turf or mud; other trunks would then be laid horizontally upon the uprights, and covered over with boughs and rushes, or turf—and the primitive hut would be completed. As the damp penetrated to their dwellings, they would find the necessity of laying a flooring of timber, and raising the roof by rafters meeting at an angle to throw off the wet. A hut so constructed would suffice for all the material wants of its occu-

BRIDGEWATER HOUSE.

CHARLES BARRY, Esq., R.A., Architect.

(*With an Engraving, Plate* VII.)

ELEVATION OF THE WEST OR GARDEN FRONT.

LITTLE remains to be added to what was said of this work of Mr. Barry's, in No. 156 of our *Journal* (Vol. XII. p. 1), when we gave an elevation of the south front. One thing which we may here do, is to correct an error that may mislead some of our distant readers as to the precise locality of the mansion, the engraver having put "St. James's Park" on the plate instead of the Green Park. That the first-mentioned is not the actual situation is perhaps to be regretted, for where it now stands Bridgewater House is not seen to full advantage, the site being far more favourable as regards the view *from* its windows, than for affording that satisfactory view of it, and that close inspection which so finished a piece of architecture is intitled to. Could this palatial town residence and Apsley House be made to change places, the entrance to Piccadilly would be really imposing, though its imposingness would partake also of imposition, by leading strangers to expect to find many other noble and aristocratic mansions of a similar class, in which we need not say they would be grievously disappointed; whereas the insipid, humdrum style, or no-style, of Apsley House promises so very little for anything else of similar kind that even the *mesquinerie* of Buckingham Palace excites less astonishment than would else be the case.

The two elevations which we have now given of Bridgewater House render description superfluous, since it would be only re-iterating what may be far better understood from the engravings. And, in way of remark, we have merely to call attention to the study of detail, and the solicitous finish exemplified in this edifice, and which contrasts so strongly with the carelessness and inequality of design, that detract considerably from the general merit of even some of our best buildings. Of the interior of the Earl of Ellesmere's mansion we are at present unable to speak, but hope that it will be in our power to do so on some other opportunity. The sole information relative to it we can here give is, that since the house was begun the plan has been considerably altered—in one respect at least—as there will now be a spacious central hall the entire height of the building, with colonnades around it, on the level of the principal floor, instead of two small inner courts with the first flight of the grand staircase carrried up between them; according to which arrangement what will now be open colonnades would have been closed gallery-like corridors, lighted from their ceilings.

LECTURES ON THE HISTORY OF ARCHITECTURE;

By SAMUEL CLEGG, JUN., M.I.C.E., F.G.S.

Delivered at the College for General Practical Science, Putney, Surrey.

(PRESIDENT, HIS GRACE THE DUKE OF BUCCLEUCH, K.G.)

Lecture VI.

ORIGIN OF GREEK ARCHITECTURE.—THE THREE ORDERS.

THERE is no country whose early history is more involved in obscurity and fable than that of Greece. As Josephus remarks, speaking of the Greeks: "As for their care about the writing down of their histories, it is very near the last thing they set about." The Greeks were an ardent and imaginative people, proud of their country, and regarding as barbarians all those who had no claim to the Hellenic name. Their early historians were bards, or rhapsodists, whose recitations, describing the deeds and events that led to the glory of Greece, were listened to with eager interest. Thus, every action and circumstance was painted in the glowing hues of poetry. They disdained an earthly parentage for their heroes, whose descent they traced from nymphs and divinities, and believed that the gods themselves came down from Olympus to take part in their conflicts, or to contest the privilege of presiding over the rising states and cities of their favoured land. The return of the Heraclidæ, and the founding of the kingdom of Lacedæmon, took place about 1104 B.C. Before this, colonies had settled in Ætolia, and the Bœotian Thebes was a flourishing city. In 1044, fresh colonies went out to Ionia; and a band of Greeks had established themselves on the southern shore of Italy, the germ of Magna Græcia. Apollonia, and other cities along the western coast of Greece, were founded by the Corinthians, who carried with them the sacred fire that, if extinguished, might only be rekindled at the holy altar of the mother state. Then followed the foundation of Syracuse, Gela, and other Sicilian cities. Thus, the Hellenic race spread themselves not only over Greece, but in Asia Minor, the south of Italy, and Sicily; shedding over all these countries the light of that genius that seemed their birthright.

A kind of rude Doric and Ionic already existed in Phœnicia, though not formed into those express combinations that could claim the name of "Order." It is probable that the Greeks received their first ideas upon the art of building from that country; but, in the true artistic spirit, they so harmonised and fitted it to their peculiar habits, institutions, climate, and materials, as to have made it so completely their own that it is not worth while to wander in search of its birthplace: it may therefore be accepted, in its early forms as in its fullest development, as *de facto* Greek architecture.

Nature seemed to have combined in that one spot of earth everything that could tend to the advancement of art, that mankind might for once behold perfection. In no age or country has the training of youth so fully called forth the united physical and intellectual powers: the body was strengthened and invigorated by athletic exercises, and the mind enlarged and elevated by the sense of freedom, and a certain responsibility in the state. Equally removed from the severity of the north and the enervating tendencies of the tropics, the frame received elasticity and force, combined with softness and grace. The spirit of rivalry amongst the small states into which Greece was divided, leading to contests of skill in the Olympic and other games, and frequently to struggles of a less peaceful nature, kept their energies awake, and forbade them to sink into the feebleness of repose. The influence of a serene and sunny climate, and a constant familiarity with the grand and beautiful scenes of nature, raised the imaginative faculty to the highest pitch. The Greek saw around him majestic mountains, sinking in picturesque declivities to the cultivated plain below; the island-studded sea, reflecting in its pure depths the azure of the heavens; what wonder that he was haunted by beauty as with a spell, and strove to reproduce in art the ideas of sublimity and loveliness with which he was inspired? Italy, from the same cause, has been the land of painting and of song: but the inexhaustible stores of marble inclosed within her mountains, seemed to denote that nature intended Greece to produce those transcendent works of architecture, and sculpture also, that have been a lesson to all successive ages.

There can be no doubt that construction in wood was the original type of Greek architecture. From such an origin alone could that proper balance of thrust and resistance, that nice adjustment of parts, and accurate knowledge of strength and weight have arisen, that made building first a science and then an art. Though magnificent and gigantic edifices were erected in Egypt, India, and Assyria, it is undoubtedly the fact, that the wooden hut first led to those combinations that produced "The Orders;" and Greece therefore pre-eminently claims our attention as our first mistress in the art, and Greek architecture as the parent of all succeeding styles. Though the wooden hut was the original type, we cannot imagine the log cabin of an indigent peasant to have been the immediate precursor of a splendid stone edifice, fit to adorn a city; nor can the bringing to perfection the wooden model, nor the imitating it in stone, nor the establishment of the orders, be referred to any one individual, or single point of time. No art can be said to be invented, much less one so complicated as architecture: its forms and proportions could only take their rise slowly from the bosom of time and experience. We must suppose that the builders of the first cabin only raised such a structure as would be necessary to shelter them from the inclemency of the weather, and were determined in the form by the nature of the materials at hand. The arid plains of the south and east were left behind with their scanty growth of palm and poplar; and dense forests were spread on all sides, offering a new and plentiful material to the ingenuity of the first settlers. They therefore hewed trees, and placed their trunks upright in the ground to support the roof, filling-in the intervals with intertwining branches made weather-proof with turf or mud; other trunks would then be laid horizontally upon the uprights, and covered over with boughs and rushes, or turf—and the primitive hut would be completed. As the damp penetrated to their dwellings, they would find the necessity of laying a flooring of timber, and raising the roof by rafters meeting at an angle to throw off the wet. A hut so constructed would suffice for all the material wants of its occu-

pants. But as man becomes civilised, the love of the beautiful arises—his eye requires to be pleased, as well as his mere physical necessities provided for; and from this faculty of our nature the fine arts result. First, the bark would be stripped from the tree, and the trunks that were to serve as uprights, rounded smooth.* The beams would be squared, and a more efficient support given to them by square slabs placed upon the pillars. Amongst a rich and agricultural people, other improvements would gradually take place; and decoration would follow, until the wooden structure was perfected, with its stylobate, columns, entablature, and pediment, adjusted to the nicest proportions that experience and taste could dictate. The poems of Homer inform us that the first temple at Delphi was of wood; and it is supposed that the old Temple of Neptune at Mantinea was constructed of the same material. After a time, as wealth and luxury increased, and more elaborate edifices were required, brick and stone began to replace the primitive materials; but, at first, only partially. We have seen that in the Etruscan temple, both stone and wood were used; and it is highly probable that this was the case, also, in the older Greek temples, as we read of so many being destroyed by fire. The second temple at Delphi, built by Agamedes and Trophonius, the Hecatompedon at Athens, and several others, shared this fate; a catastrophe which could scarcely have happened had they been, like the Parthenon, entirely of marble. Remains of construction in brick are also met with; though these, in a country abounding in stone, like Greece, are rare. The walls of Mantinea are of crude brick. At Argos are vestiges of a temple of terra-cotta; and another example existed in a portico at Epidaurus. Even in building in wood, certain maxims must have impressed themselves on the minds of the first architects, such as that the heavy should support the light, and the strong the feeble; that solidity should not only be real, but apparent; that nothing should be introduced, even in the way of ornament, without its seeming to arise from some necessity in the construction, as nothing can be beautiful that is not appropriate; and that all the parts and details should be subordinate to the whole. In course of time, as buildings for different purposes were required, three orders, or distinct combinations, were formed, each differing from the others, and taking their rise from different ideas. The Doric, expressive of grandeur, strength, and solidity; the Ionic, of dignity combined with elegance and grace; and the Corinthian, of lightness and festive sumptuousness: and these ideas, notwithstanding the infinite modifications of which the orders are susceptible, were always kept distinct. As the original type of the wooden structure is more closely adhered to in the Doric than in the other orders, it has been generally considered as the earliest; though there is no foundation for such a supposition. According to Vitruvius, the Doric order was invented by Dorus, the son of Helen and the nymph Optieus, who governed the whole of the Peloponnesus, and dedicated a temple to Juno, in the city of Argos; and that this order of architecture was adopted by the cities of Achaia, and from its inventor received the name of Doric. But such a fabulous origin proves nothing beyond its antiquity; nor is a name any better guide—for instance, no vestige of the order called Corinthian is found in Corinth, nor does the acanthus grow plentifully in its neighbourhood. A name is often given to a style long after its introduction, and arises sometimes from the country where it was most generally in use, sometimes from some artist by whom it was embellished, or other fortuitous circumstance.

The principal features of the Doric order are, the massive column springing direct from the stylobate, without base, and tapering considerably towards the capital; the bold ovolo, or echinus, and projecting abacus with which the column is crowned; the solid architrave, and enriched frieze, calling to mind the primitive forms from which it took its rise; and the cornice composed of few but varied lines,—altogether forming a combination of unequalled simplicity and grandeur.

Vitruvius tells us that the first architects, in the absence of fixed proportions, bethought themselves of measuring the human figure: and, finding the length of the foot one-sixth the height of a full-grown man, they adopted this as the proportion, making the column six diameters high. This rule, however, is proved to be fallacious, by actual admeasurement of the Greek Doric, in the best examples of which the columns are not as much as six diameters in height. Moreover, architecture does not imitate nature, but proceeds on the same principles as nature herself. In an organic structure there are certain proportions which are never overstepped—certain adaptations of parts to a whole, which are always preserved; though, within these limits, there is perfect freedom. Thus in a skeleton, if we see one bone, we can at once decide to what species it belongs; and yet the individuals of that species are so infinitely varied that no two are exactly alike. Thus worked the architects of Greece, in the secondary forms and proportions, adhering to no positive rule, but varying them according to the dictates of taste and judgment. Nor should this excite our surprise; rules never produced a work of genius; they are the result —the effect, not the cause of such works. A great artist arises; his productions transcend all that has gone before, and at once command the suffrage of the public: they become an example—a rule. But let the student beware of imagining that, by exactly following such rules, he will achieve like results. As well might a painter take a *chef d'œuvre* of Raffaelle's, and say, by following such and such lines, and imitating such and such masses of light and shade, and combinations of colour, I shall produce a picture like this; or a musician fancy he could compose a symphony like one of Beethoven's by studying thorough base. The most that could result from such a course of study would be a cold correctness, that might not offend, but would utterly fail in commanding admiration. It was a saying of Michael Angelo's, "that the man who follows another is always behind; but he who boldly strikes into a different path, may climb as high as his competitor." Rules are valuable to repress exaggeration and extravagance—they serve to mark the limits beyond which grandeur and energy would be lost in clumsiness, or elegance and grace degenerate into poverty and weakness; but within these extremes the imagination may stray at will. Those who would make architecture nothing but a system of rules, would render it no longer an art, but a mere mechanical trade.

In architecture, the constituent parts of every structure, however vast and complicated, are composed of a few elementary forms; thus, the buildings of the Greeks may be divided into four principal parts —the platform, or stylobate; the columns, serving as supports; the entablature, connecting and resting upon these; and the pediment and roof, crowning the whole. The character of the order is not confined to one part, but is spread over all; but the column is the indicator and regulator: thus the names of the different orders are given to the supports, according to their style. Hence they are called Doric, Ionic, or Corinthian columns. It is impossible to assign any chronological order to the ancient edifices of Greece. Generally speaking, in the earlier examples, the column is more massive, with fewer flutings, and supporting a heavier entablature; but this is by no means an infallible rule. Nor can we trace the rise of Greek architecture from progress to progress, as in other styles, for the temples of the remotest antiquity are as beautiful and complete as those of a later date. The hypæthral Temple of Pæstum is scarcely, if at all, inferior to the Parthenon itself. Indeed, Signor Lusieri (a great authority in matters of taste) considered the Temple of Pæstum as an example of a more correct and pure style; and thought that the Doric order there attained an excellence beyond which it never passed. He observed, "Not a stone has been placed there without some evident and important design; every part of the structure bespeaks its own essential utility." His opinion was the same with respect to the ancient Temple of Jupiter Panhellenius, in Ægina: "Of such a nature," said he, "were works in architecture, when the whole aim of the architect was to unite grandeur with utility, the former being founded on the latter: all then was truth, strength and sublimity." It was not until the year 1745 that attention was drawn to the ruins of Pæstum. Though in the year 1675, Athens was visited by the Marquis de Nointel, Dr. Spon, Sir George Wheler, and Mr. Vernon, who all published the result of their researches, the architects of that day knew so little of the pure Greek Doric, that the temples at Pæstum were for some years considered as unique; and in France this style was called the order of Pæstum, and it was not until Messrs. Stuart and Revett went to Athens in 1751, that the beautiful remains of Greek architecture were made known to the public.

When the ruins of Pæstum were first examined, in the total absence of history or inscriptions, many speculations were afloat respecting their origin. Signor Paoli imagined them to be Etruscan, because Pæstum, then called Phistu, was in existence before the Greek orders were known, Jason having offered libations there; but the Chevalier Boni very truly remarks, that such a tradition "only proves the antiquity of the place itself, not of everything it contains." Pæstum was one of the earliest Greek settlements in Italy; and by them called Poseidonia. Mr. Wilkins, speaking of the hypæthral temple (supposed to have been dedicated to the tutelary deity of the city, Poseidon, or Neptune), says, "The Grecian character is too strongly marked to admit of any argument, and must have been coëval with the very earliest period

of the Grecian migration to the south of Italy. Low columns, with a great diminution of the shaft, bold projecting capitals, a massive entablature, and triglyphs placed at the angles of the zophorus, are strong presumptive proofs of its antiquity." The pseudo-dipteral temple does not belong to a period of such correct taste; indeed, it has been supposed to be of Roman rather than Greek workmanship. The columns have a pecular capital—a row of small leaves encircle the neck, and turn over, as if supporting the lower fillet. These temples are built of a kind of stalactite, of the same nature as the travertine, formed by a calcareous deposit. The Temple of Ægesta, or Segesta, in Sicily, is another ancient example of the Doric; it is, I believe, the only instance in which the columns were unfluted. In several ruins, the columns would appear at first sight to be plain; but the Greeks did not work the flutings till after the column was raised, the channels under the capital, and at the base, being previously marked to serve as a guide to the workmen. In some instances the columns were left unfinished; though the above-mentioned marks may still be detected. In the ruins of the Temple of Apollo Didymæus, near Miletus, there are two fluted columns yet standing, and one plain; but with the channels marked above and below. There is a wide interval of time between the building of the hypæthral temple at Pæstum, and that of Jupiter at Agrigentum, which was left unfinished at the time of the destruction of the city by the Carthaginians, 405 B.C. Nevertheless, no great difference is apparent in the style, only that diversity of proportion and detail which is always seen in Greek architecture. It was said of the Agrigentines, that they pursued pleasure as if they had only a day to live; and built as if they were never to die. The gigantic proportions of the Temple of Jupiter brings this saying to mind, the lower diameter of the columns being 12 ft. 11·7 in., and their height 63 ft. 4·6 in. According to Diodorus, a man could stand in each fluting. There were three other considerable temples at Agrigentum, and several at Selinunte, another ancient Greek town in Sicily. All these temples were of the Doric order, and yet not two precisely similar; showing that the same design was never repeated even in one city. In the Temple of Neptune at Pæstum, the columns are only four diameters in height; those of the old temple at Corinth bear the same proportion. The columns of the Temple of Theseus in Athens, were rather more than 5 diameters high; of the Parthenon, nearly $5\frac{1}{2}$; of Jupiter at Agrigentum, 5 diameters; in the Temple of Apollo Epicurius at Bassæ, the columns are rather more than $5\frac{1}{2}$ diameters high; and as we approach a later and less correct age, the proportions are still more slender. In the Portico of Philip at Delos, the columns are $6\frac{1}{2}$ diameters in height.

It does not appear that the entasis was used in the more ancient examples; indeed, it would naturally be one of the last refinements of art. The columns of the Temple of Neptune at Pæstum, have been proved to be without entasis, though not always so represented. Pæstum, since its desertion, has become a perfect marsh; and the damp eating away the stone at the lower part of the column, has given them the effect of swelling in the middle. The column, in the ancient Doric, appearing to diminish too rapidly, would cause some architects to endeavour to remedy this defect. This was done by slightly increasing the diameter towards the middle of the column, though always keeping it within the lower diameter. This swelling out, called by the Greeks "entasis," should not be visible, being only intended to give the effect of a gradual diminution. Mr. Cockerell was the first to discover the entasis in the columns of the Parthenon. In a degenerate age, this refinement was exaggerated, as in the pseudo-dipteral temple at Pæstum; and thus became a defect instead of an additional beauty.

The number and manner of the flutings in the Doric shaft varied considerably. There is a ruin of a Temple of Apollo Thearius at Trœzen, in Argolis, the columns of which have eight plain sides. In the Portico of Philip at Delos, the upper part of the shaft is fluted; while the faces are plain towards the lower diameter. In a Doric temple at Orchomenus, in Arcadia, the columns have 18 flutings; in the ancient temple at Corinth, 20; and in the Temple of Neptune, Pæstum, 24. The flutings in this order are shallow and meet at an edge, without intervening fillet.

The custom of fluting the shaft has never been satisfactorily traced to an origin, some supposing it to have arisen from the grooves formed in wooden pillars by the water trickling down; other from the stalks of plants; and others, again, from observing the fluted shell common on the coast of Greece. Probably, the columns were in the first instance polygonal, the channelling being a subsequent improvement.

The simple abacus of the Doric order is a representation of the primitive square block, placed on the pillar for the better security of the beam. The echinus or ovolo would result from bevelling off the abacus to meet the shaft; such a capital was found in an Etruscan tomb at Bomazzo. The ovolo afterwards became a separate member, and was quirked under the abacus, and moulded into a more elegant form, by increasing taste.

The profile of the Doric capital varies in each building, the form of the ovolo depending upon its depth and the projection of the abacus, the general proportion of the latter being to the lower diameter, as 1·25 to 1. The ovolo is united to the hypotrachelium, or neck, by several fillets, varying in number from three to five. In some examples they are omitted; but these are rare. The same variety is seen in the number of annulets encircling the neck of the shaft. In the Temple of Neptune there are three; in the Parthenon one; and in other instances the flutings are continued up to the fillets, without interruption. The intercolumniations in the Doric order are narrow, adding to the general character of grandeur and solidity. One diameter is the general proportion, but in some examples they are $1\frac{1}{2}$; and in an ancient temple in Sicily, less than one diameter.

The Doric entablature is massive and simple, and divided into few parts, the proportion being nearly two diameters in height. The architrave or epistylium is plain, with the exception of the guttæ.

In most of the Greek buildings, the architrave, instead of being even with the upper diameter of the shaft, projects so as to be nearly on a line with the lower diameter; but to prevent this superincumbent weight from crushing the projecting part of the abacus, there is a slight space left at the outer edge, which throws the weight on the centre of the capital, and at the same time gives greater distinctness of outline. The frieze is the only part enriched, though the decoration strictly recalls the primitive type. The word "frieze" is derived from the Italian *fregio*, ornament, which is taken from the Latin *phrygius*, embroidery. The Greeks and Romans gave this member the name of zophorus, or figure-bearing. The triglyphs represent the ends of the joists resting upon the beam. It was the custom, anciently, to lay these joists upon the tie-beam, of such a length as to project considerably beyond the external face of the wall, as may be seen in the Etruscan temples. In later times, to improve the appearance, the ends were cut away even with the beams. It is supposed that the three glyphs or grooves are traditional, and that such notches were cut in the ends of the joists to allow the water to run off; the drops hanging below being represented by the guttæ. Others think the triglyph was originally a mere ornament: to conceal the ends of the joists in wooden buildings, we are told the ancients used to cover them with blue wax, by way of decoration. In some examples the triglyphs are not carved on the block of the frieze, but on a separate slab of stone fastened on. The Greeks always placed triglyphs at the angles of the frieze; this was probably done, to present the subjects carved on the metopæ in an uninterrupted series.

To obviate the difficulty of the end metope being thrown out of proportion, the end triglyphs were slightly enlarged, or the intercolumniation at the angle narrowed; an example of this last method is seen the Temple of Theseus at Athens.

The guttæ were either rectangular or conical; or, as is universally the case in Sicily, cylindrical. They were always six in number. In ancient times the metopæ were open spaces between the triglyphs. This is mentioned in a passage of Euripides, where Orestes and Pylades are concerting a plan for carrying off the image from the Temple of Diana. Pylades recommends his friend to creep through the opening between the triglyphs, and so gain access to the interior of the temple. The spaces were afterwards filled-in with slabs; and lastly, the metopæ were enriched with bas-reliefs, the subject being always appropriate to the service of the temple.

The cornice of the Doric order is bold and simple: its characteristic is the mutule, representing the ends of the rafters composing the roof. The mutule was decorated with three rows of guttæ, six in each row. The mutules were never repeated along the cornice of the pediment, as in some modern examples: the Greeks had too much taste to represent in sculpture what could not have existed in reality.

In the Temple of Neptune at Pæstum, and that of Jupiter Panhellenius in Ægina, the upper member of the cornice is a cavetto. In many other temples it is an ovolo. The cyma was not an integral portion of the early Doric; indeed, it is not supposed to have become an established part of the order until after

the age of Alexander the Great; where the cyma is introduced, as in the Temple of Apollo Epicurius, it is generally enriched. The Doric pediment was slightly less elevated than in the other orders, giving it a graver character; the tympanum was sufficiently deep to allow of statues being placed within. Thus every part of the Doric order was calculated to impress the idea of strength, sublimity, and energy; not only by the massiveness of its proportions and the simplicity of its details, but by the boldness of relief given to all its mouldings and ornaments—adding, by deep masses of light and shade, to force and grandeur of outline.

It is quite as impossible to trace the history of the Ionic as of the Doric order; but we have no reason to suppose it of a less ancient date. As before mentioned, Vitruvius informs us that the proportions of the human figure were adopted, the Doric representing the manly stature, and being employed in erecting temples to the gods. But, he adds, the Ionians now wished to dedicate a temple to Diana, and sought to invent a new order in her honour. This they did by giving the column the proportion of the female figure, that it might be emblematical of feminine delicacy; so the columns were made eight diameters high, and had bases given to them in imitation of sandals. The volutes represented the ringlets on either side the face, and the flutings the folds of the garment falling to the feet; they thus presented the likeness of a woman richly adorned. This account is evidently more fanciful than correct.

Other authors think the Ionic order may have been borrowed from India or Persia; and other more imaginative writers have fancied a resemblance to the volute in the curling bark of the first rude wooden pillar.

The idea of the volutes being imitated from the horns of goats or rams appears much the most probable. Altars were erected to the gods long before temples were thought of. These altars were usually decorated with, and sometimes wholly composed of, the skulls and horns of the animals slain in sacrifice; and as far back as history leads us, the ancients built their altars with horns at the corners. "The horns of the altar" is an expression frequently met with in the sacred writings; thus, in Exodus xxxviii. 1, 2. "And he made the altar of burnt offering of shittim wood;" "and he made the horns thereof on the four corners of it:" and in the 1st Kings, ii. 28: "And Joab fled into the tabernacle of the Lord, and caught hold on the horns of the altar." The use of these horns is explained in Psalms, cxviii. 27, where the psalmist exclaims, "Bind the sacrifice with cords, even unto the horns of the altar." When temples were erected, these horns might very probably have been represented as ornaments on the capitals of the columns.

Hermogenes of Alabanda, and his colleagues, who were employed in the restoration of the temples of Asia Minor after the Persian invasion, brought the Ionic order to great perfection. They maintained that the Doric was unfit for temples; and from this time the Ionic order prevailed as exclusively in Asia Minor as the Doric in Magna Græcia. In the latter country the Doric may have become sacred from association, recalling the mode of construction of the mother country; but in Asia Minor, where the wooden dwellings were still in use, and where they have continued even to the present day (the huts of the peasantry still showing the primitive type), this order may have become too familiar to be associated with the service of the temple; and the volutes having a religious origin, the Ionic would consequently be preferred.

Though the Ionic always retains its distinctive characteristics, it varies in detail quite as much as the Doric. In this order, expressive of grace and elegance, the parts are multiplied—a base is given to the column; the shaft is made more slender; the diminution from base to capital less; the number of flutings is increased (the best examples having twenty-four), they are also divided by a fillet, and channelled to a greater depth; the architrave is composed of three bands or fasciæ; the ornaments on the frieze, recalling the wooden structure, are suppressed; the denticulus replaces the Doric mutule; and each member and moulding is made more delicate in outline, as well as more elaborate in decoration. The Ionic does not appear at first to have been so distinct an order: several instances exist, especially in Sicily, of Ionic columns with a Doric frieze; these are supposed to be very ancient. The earliest mention of the Ionic order, is met with in Pausanias, where he describes the Treasury at Olympia, erected by Myron the Tyrant of Sicyon, about 650 B.C., as having two chambers, one Doric, the other Ionic. Next follow the Temple of Diana at Ephesus, and the Heraion or Temple of Juno at Samos; of the first, we have nothing left but vague description: Herodotus mentions the latter as being one of the most stupendous edifices built by the Greeks, and was completed about 540 B.C.

The small Ionic Temple on the Ilissus is one of the most ancient, the ruins of which still exist; the columns are only eight diameters in height, the upper torus of the base is fluted, and like that of Juno at Samos, the lower torus rests upon the stylobate without intervening plinth. The capital is simple but elegant, the lower band has a graceful curve between the volutes, and the channels have a double border. The entablature is two diameters in height; the arhitrave is plain without the usual fasciæ; the denticulus is also omitted. The frieze is supposed to have been originally decorated with bas-reliefs.

We learn from Pausanias, that on the opposite side of the Ilissus stood an Ionic temple dedicated to Eucleia, or illustrious Fame. On the very spot described, a singular Ionic capital has been found built into the wall of a modern edifice: no doubt this capital belonged to the "naos of Eucleia." The upper diameter of the shaft is 1 ft. 1·65 in.; a star-like flower occupies the centre of each volute: the lower band instead of forming a continuous curve between the volutes, turns up again, each side terminating in a flower and two tendrails. Another flower is carved in the centre of the capital. As far as we know it is unique, and probably of very early date.

In the celebrated Temple of Bacchus at Teos, built by Hermogenes, the columns are $8\frac{1}{2}$ diameters high, and of the two porticoes of the Erechtheion, those of the northern or Minerva Polias are 9, and those of the eastern portico $9\frac{1}{2}$ diameters in height. In another often-cited example, the Temple of Minerva Polias, at Priene, not one column remains entire; it is therefore impossible to ascertain the exact elevation.

The bases and capitals vary in each example. In the Temple of Bacchus, the Athenian base is seen; in that of Minerva at Priene, the Ionian: both these are proper to the order. The Athenian consists of two tori, with a scotia between, separated by small fillets. The Ionian of two scotiæ, with two astragals both above and below, as well as between them; over all is a large overhanging torus. This produces the unpleasant effect of being weak, and liable to snap below the heavy torus.

According to Pliny, the Ionian base was first introduced in the Temple of Minerva at Priene, and as this temple was completed and dedicated by Alexander the Great, it belongs to a period when Greek art had already begun to decline, when a minute attention to detail had taken the place of general boldness of design. In the capitals of the Temple of Bacchus the channel connecting the two volutes has no border on the lower edge, but terminates in a horizontal line tangent to the commencement of the second revolution of each volute. The Ionic order is found in its most elaborate and beautiful form in the double temple called the Erechtheion at Athens; but as this building will be described at length in another place, it is not necessary to give it further mention here.

In the Greek Ionic, the volutes present a flat face on the two opposite sides of the capital, the flanks or balusters being generally formed like two cones, united in the centre by an ornamented band or fillet. In the angular columns the volutes are contrived to present the same face in flank as in front, and the returns are likewise placed at right angles instead of on opposite sides.

The third and most sumptuous order, the Corinthian, is more slender in its proportions than either the Doric or Ionic, "with an intention," according to Vitruvius, "to make the form of the column accord with the more delicate proportions of the maiden figure." The invention of this order has been given to Callimachus, and the following pretty story is related by Vitruvius, as giving rise to the idea:—A Corinthian virgin, who was of marriageable age, fell a victim to a violent disorder; after her interment, her nurse, collecting in a basket those articles to which she had shown a partiality when alive, carried them to her tomb, and placed a tile in the basket for the longer preservation of its contents. The basket was accidentally placed on the root of an acanthus plant, which, pressed by the weight, shot forth towards spring its stems and large foliage, and in the course of its growth reached the angles of the tile, and thus formed the volutes at the extremities. Callimachus, happening at this time to pass by the tomb, observed the basket and the delicacy of the foliage which surrounded it. Pleased with the form and novelty of the combination he took the hint for inventing these columns, using them in the country about Corinth."

The merit to which Callimachus can really lay claim is to have fixed and determined the proportions of the Corinthian order more

accurately than it had been done before. The distinguishing feature of this order is the bell-shaped capital, ornamented with foliage, a form repeated in endless diversity amongst the Egyptians more than 1000 years before the time of Callimachus; and Josephus tells us that the roof of the Hall of Justice in Solomon's Palace was supported by pillars of the Corinthian order. The bell-shaped capital from its height, and its capability of being highly ornamented, is particularly suitable to an order intended to surpass all others in richness and lightness of effect, and the difference between the Egyptian lotus flower capital and the Greek Corinthian, is no more than would result from its adaptation by a people of taste and genius.

The following proportions are laid down by Vitruvius for the Corinthian capital:—"The height including the abacus is equal to the lower diameter of the columns, and the diagonal line, drawn from the opposite angles of the abacus, is twice the height of the capital. All the fronts of the abacus are of equal extent, and are made concave, the central point in each front receding $\frac{1}{9}$th part of the extent comprehended between the angles. The diameter of the capital at its base is the same as that of the columns below the astragal and apothesis. The depth of the abacus is $\frac{1}{7}$th part of the whole height of the capital, the remainder is equally divided into three parts, one of which is occupied by the lower leaf, the second is given to the middle leaf, and an equal space remains for the cauliculi, whence those leaves shoot which projecting forwards appear to support the volutes. The volutes spring from the leaves of the cauliculi, and extend to the angles of the abacus: the lesser helices are carved in the middle of the capital below the flowers in the abacus, and are made as large as the height of it will admit."

How little these rules are applicable to the generality of Greek Corinthian capitals may be seen by referring to the two most perfect examples now remaining—the capital of the Choragic monument of Lysicrates, and that of the Tower of the Winds, both in Athens.* If the rule always held good that the simple precedes the elaborate, we should ascribe to the latter the earliest date; but that is not the fact. The most ancient known example of Greek Corinthian is a column in the interior of the Temple of Apollo Didymæus, built by Pæonius, 479 B.C. The Choragic monument of Lysicrates was not erected till the year 355 B.C. In this capital the lowest row consists of plain water leaves; then follows a row of acanthus, with flowers between the leaves; above these are the cauliculi with large bold volutes, supporting the abacus. One great singularity in these columns is that the flutings of the shafts terminate above in leaves. It has been supposed that the vacancy left between the shafts and the capital was originally occupied by a metal astragal. The Tower of the Winds at Athens, dates 159 B.C., but the beautiful curve of the bending water leaves, and the exquisite forms of the acanthus, mark this capital as a work of pure Greek art. A similar capital was found among the ruins of the Bœotian Thebes, and another in the island of Milo has two rows of acanthus below the water leaves.

The Temple of Jupiter Olympius at Athens is generally cited as an example of the Greek Corinthian in its most perfect form, differing but slightly from the rules of Vitruvius; but it is doubtful whether either this temple, or that of Jackly, near Mylasa, can be said to be purely Greek. The Greeks never applied the Corinthian order to the exterior of sacred buildings, but confined it strictly to structures of a light and ornamental character, and to interior decoration. There are instances where the Ionic order has been employed in the interior of Doric temples, of one Corinthian column being placed at the end of the cella, as if to continue the gradation: this was the case in the Temple of Apollo Didymæus, and in that of Apollo Epicurius at Bassæ.

Though the Temple of Jupiter Olympius was originally commenced by Pisistratus, and for a time continued by his sons, it was left a mere foundation until the time of Antiochus Epiphanes, 400 years afterwards. We have no proof that it was originally intended by Pisistratus to be of the Corinthian order, nor is it likely that he should in that age have so far violated the feelings and customs of the Greeks, as to have dedicated that light and festive order to the supreme divinity; besides, Pisistratus died in the year 527 B.C., and Callimachus, who at any rate is allowed to have perfected the Corinthian, and given it those proportions so justly admired, lived at the end of the Peloponnesian war, which terminated 404 B.C.: so that it is difficult to believe that the capitals of these columns were designed more than a century previous to its existence, particularly when we compare them with those of the Choragic monument. When Antiochus Epiphanes undertook the construction of this magnificent edifice, he employed a Roman of the name of Cossutius, the first Italian architect on record: it was still however left unfinished, and was partly destroyed by Scylla, and at last restored and completed by the Emperor Hadrian, 700 years after its first foundation.

The Temple at Jackly is open to the same objection, being also of the time of Roman domination, when Roman taste had already begun to prevail over the pure and severe style of the Greeks. The Corinthian order is susceptible of great diversity—the shaft may either be plain or fluted; the Attic base is usually employed. The upper torus is sometimes doubled; as in several examples in Asia Minor; the tori are generally enriched with the guilloche or other ornament. The Corinthian entablature has nearly the same proportions as the Ionic, and, like this order, the frieze may either be plain or elaborately adorned. The distinguishing feature of the Corinthian cornice is the modillion; but from the before-mentioned scarcity of examples of this order in Greece, it will be described more at length in treating of the architecture of Rome.

I have now endeavoured to sketch the portraits of the "Three Orders," as they were practised in Greece; in my next lecture I propose to take a survey of Athens, as a type of an ancient Greek city, and as the principal school of art. I shall then proceed to describe the temples, theatres, and other principal edifices of Greece, showing the manner in which the orders were applied.

LIST OF AUTHORITIES.

Vitruvius.—Antiquities of Athens, Stuart and Revett.—Antiquities of Ionia, Dilettanti Society.—Antiquities of Magna Græcia, Wilkins.—An Inquiry into the Principles of Beauty, Lord Aberdeen.—Encyclopædia Methodique, G. de Quincy.—Architettura Antica, Canina.—Tour in Greece, Dr. Wordsworth.—Travels in Greece, Clarke,—Travels in Greece, Chandler.—History of Greece, Grote.

REPORT OF THE COMMISSIONERS

APPOINTED

TO INQUIRE INTO THE APPLICATION OF IRON TO RAILWAY STRUCTURES.

(*Continued from page* 116.)

We owe some apology to our readers for delay in noticing the admirable series of experiments instituted by the "Iron Commission," to illustrate the effects of loads travelling along girders. The experiments may be divided into two classes—those performed at Portsmouth by Captain James and Lieutenant Galton, and those performed subsequently and independently by Professor Willis at Cambridge.

In both sets of experiments the principal characteristics were the rapid transit of loaded carriages over horizontal bars, and the method of producing the velocity of transit by causing the carriages previously to descend an inclined plane by the accelerating force of gravity. The loaded carriages ran on a railway on the inclined plane, and the oblique descending motion was converted gradually into a horizontal one by connecting the inclined and horizontal portions of the railway by curved rails, which avoided the abruptness of transition from one straight line of rail to another.

The motion of the carriage, then, previously to its reaching the beam to be deflected, is horizontal, and therefore comes on the beam under circumstances precisely analogous to those under which a railway train in practice passes over a bridge. And yet the absurd speculations which have been hazarded on this point! We have heard—but sincerely trust that our information is incorrect—of quasi-philosophers undertaking to gravely, even publicly, criticise the method of experiment on this ground—that previously to coming on the beam the experimental carriage had acquired, by its motion on the incline, a *downward tendency or momentum, which might have been the real cause of the increase of deflection of the girder!!*

There is something almost ludicrous, if it were not very pitiable, in the fact that Professor Willis has had to defend himself against such cavillers as these—men, too, possessing some name and authority. What can be said to clear up such a hopeless confusion of ideas? It would be idle to answer, that after the motion of the carriage has become horizontal, it is perfectly unaffected by any motion which it had a minute or a twelvemonth previously. We had, on commencing this paper, some idea of endeavouring to argue the point seriously, but further reflection shows the hopelessness of the attempt. All that can be done is to lament the prevalent ignorance of sound dynamical principles which such a

* See Stuart and Revett.

melancholy exhibition indicates. Engineers incur most serious responsibilities in providing for the security of railway travelling, which are faithfully discharged by those only who possess sound and scientific knowledge of mechanics—not by those who content themselves with the inaccurate undigested notions which they call *practical knowledge*. Until such discussions as that above referred to, have ceased, there will be always a well-grounded apprehension that the assumption of scientific rank is a mere cloak of quackery, empiricism, and presumptuous incompetence.

Of the two series of experiments upon the dynamical deflection of girders, those conducted at Cambridge by Professor Willis must be considered the most effectual for the discovery of the mechanical laws of this subject. It is not always the most *direct* experiments which are the most conclusive. Indeed, the great art of experimenting consists in abstracting various incidental causes which have no real bearing on the question at issue, but tend merely to complicate the results from which laws are to be inferred.

Of course this abstraction of incidental circumstances, which are of real occurrence in practice, must be made cautiously and on scientific principles. Unless it be conclusively shown that the causes abstracted are immaterial, an essential link is wanting in the chain of argument deduced from the experimental results.

In the experiments at Portsmouth the carriage travelled over two trial bars at once; in the Cambridge experiments over only one bar at a time. In the former series, the load during its transit always pressed on two points of each bar at once; in the latter series only on one point. Now, the simultaneous employment of two bars introduces this difficulty—that, because it is impossible to have both exactly of the same rigidity, one will be deflected in a different way to the other; consequently there will be, during the transit, a rocking or lateral oscillation of the carriage, which unduly affects the observed deflections. Again, if two wheels of a four-wheeled carriage press at once on one bar—the bar being 9 feet long, and the axles of the wheels nearly 3 feet apart—there is an inevitable complexity. For at the commencement of the experiment only the fore wheels, at the end of the experiment only the hind wheels, press on the bars—part of the load being at those times borne by the permanent railway beyond the bars: also the theoretical computation of the curves of deflection, on the supposition of a simultaneous pressure on two points of the trial, would be of the most embarrassing nature. Consequently, it would be all but hopeless to attempt an exact comparison between the results of the Portsmouth experiments and the corresponding results of theory.

Nevertheless, the series of experiments carried on by Captain James and Lieutenant Galton were very valuable in themselves—for they exhibited distinctly the effect of the inertia of the beam in resisting its dynamical deflection. It was shown in the number of this *Journal* for September 1848, in the paper on *The Dynamical Deflection and Strain of Railway Girders*, by Mr. Homersham Cox, that when the inertia of the load and bridge respectively bear anything like the proportions observed in practice, the increase of deflection due to the ordinary velocities of the load is inconsiderable. But in the experiments at Portsmouth the dynamical deflections greatly exceeded the statical. The results were, indeed, of a nature to surprise those who had not maturely considered the whole question; but this apparent contradiction of the daily experience of railway travelling ceased when it was reflected that the trial bars were purposely made very light, so that their deflections might be large and easily observed. The relation between the sustaining and moving masses entirely differed from practical proportions; and the beam possessed so little resistance of inertia (to adopt loose phraseology) as to be susceptible, in an excessive degree, of dynamical influence.

In the experiments conducted by Professor Willis, several refinements were introduced, and a beautiful mechanical contrivance was employed by him, which showed, with great precision, the effects of inertia, and explained "the great and startling increments of the deflection" above referred to. The contrivance in question was termed by the Professor the *Inertial Balance*.

The mechanism of the Inertial Balance consisted of a loaded lever, carefully poised at its centre of gravity on a fixed fulcrum, and connected by other multiplying levers with the centre of the trial bar; so that for a slight deflection of the bar the loaded lever must necessarily turn through a considerable angle. Now, it is apparent that by this contrivance the inertia of the beam was increased, but not its elastic strength. For as the balance was poised, it could have no statical effect, except that due to friction of pivots; and accepting the friction as inconsiderable, a weight at rest on the trial bar would produce the same deflection whether the balance were applied or not. But though the statical strength of the trial bar remained unaffected, its dynamical strength might be increased *ad libitum;* the moment of inertia of the loaded balance was easily comparable by known theorems of mechanics, with the effect of the simple addition of increased mass at the centre of the bar—such mass acting by its inertia only, and not by its gravity.

The balance was provided with two shifting "bobs," of equal weight, which, as they were always placed at equal distances from the fulcrum, counteracted each other's weight, but increased at pleasure the moment of inertia.

It would require too much space to describe all the other refined and ingenious contrivances which were applied by Professor Willis to secure the correct registration of the results. We must refer to the Report itself for an account of his methods of determining precisely the velocity of transit, and of applying tracing pencils at different points of the trial bar, so as to show the simultaneous deflections at those points during the whole transit.

We have no little gratification in finding that the *practical* results, deduced by the combination of his labours with the beautiful investigations of Professor Stokes, agree identically with those predicted in this *Journal* two years and a half ago, in the paper on *The Dynamical Deflection of Girders*. In the 'Cambridge Transactions' for the year 1849, Professor Stokes, after giving an analytical series for expressing the relation of the dynamical to the statical deflection, in terms of a quantity β, expressing the effect of centrifugal force, adds, "In practical cases this series is reduced to $1+\frac{1}{\beta}$. The latter term is the same as would be got by taking into account the centrifugal force, and substituting in the small term involving that force the radius of curvature of the equilibrium trajectory for the radius of curvature of the actual trajectory. The problem has been already considered in this manner by others by whom it has been attacked." The method here explained is precisely that which was given in this *Journal*, which contained the only other investigation of the problem published.

Professor Willis also gives numerical results for comparing the two kinds of deflection, which agree exactly with our own, except that he has given the ratios in decimals which we gave as vulgar fractions.

Both Professors Willis and Stokes object, however, to one conclusion in the "able paper by Mr. Cox." In the 'Cambridge Transactions,' Mr. Stokes's liberality of feeling towards other labourers in the fields of science, induces him to speak of the paper as one in which "the subject is treated in a very striking and original manner;" but he adds, that "among the sources of labouring force which can be employed in deflecting the bridge, Mr. Cox has omitted to consider the *vis viva* arising from the horizontal motion of the body:" and proceeds to show that taking the horizontal acceleration into account, it is *theoretically* possible that the deflection may be under certain circumstances more than double that which could be maintained statically.

Of this theoretical truth there can be no dispute, nor of the accuracy of the argument alleged in its support. A single observation however will be sufficient to remove the apparent discrepancy between the two independent investigations. That of Professor Stokes treated the subject in all its theoretical generality with the aid of all his analytical powers, and was addressed to a mathematical audience. The investigation of Mr. Cox was intended for practical engineers, and therefore regarded the subject with those limitations respecting the inertia of the beam which practice imposes. *When these limitations are introduced, the results of both papers are identical.* The opinion of Professor Willis is conclusive on this point: speaking of the paper in this *Journal*, he says:—"The author has employed methods of approximation which, although they have not apparently vitiated his results *as far as real bridges are concerned*, would cause them to fail utterly if applied to the interpretation of experiments such as those contained in the present volume."—That is, experiments in which the ratios of the mass of the beam and load altogether differ from those ordinarily adopted. Moreover, it is to be observed that the object of the paper in this *Journal* was the discussion of the deflection of the girder at the CENTRE; and for that point the conclusions of the paper still holds, even when the additional consideration of horizontal acceleration is introduced.

The observations are made not merely from personal feeling—for that would be amply gratified by the acknowledgment made of our labours—but also to show how materially the whole question is affected by the relation of the moving and sustaining masses.

Among the experiments in Portsmouth Dockyard we find a series for determining the deflection of bars, subjected to the "sudden application of weight without impact;" and another series for determining "the effects of a camber or upward convexity of the beam." Both these series, though the fact is not alluded to in the Report, were suggested in this *Journal*, by the paper above referred to, in the sections discussing the effects of *instantaneous loading* and the effects of *centrifugal force*: the experimental results amply confirm the conclusions arrived at in the paper.

The whole question of the dynamical deflection of girders must now be considered as set at rest. It is quite obvious that a thousand circumstances occur in practice which would vitiate all theoretical conclusions as to the very minute quantity which the excess of dynamical over statical deflection is shown to be. A very slight original curvature of the beam, its imperfect elasticity, a bad joint of the rails, the pulse of the engine even, would set all mathematics at defiance. However, a great service has been rendered by the investigation; the value of the result is in nowise diminished because it shows the effects of velocity to be inconsiderable. Next to security, the most important requirement of railway travelling is a conviction of security. It is the reasonableness of such a conviction, long ago demonstrated in these pages, which the admirable labours of Professors Stokes and Willis, Captain James and Lieutenant Galton, have elucidated by means of experimental induction.

SUPPLY OF WATER TO THE METROPOLIS.

On the means of Supplying the Metropolis with Pure Water and in ample quantity. By Mr. John Pym.—(Paper read at the Society of Arts.)

The author commenced by stating that the water supply of the metropolis is derived from three sources:—the New River, the Thames, and the Lea; wells sunk to different depths in the London clay, sand, and gravel; and Artesian wells. Of the water thus obtained, that from the Thames is impure, that of the New River almost as bad for a great part of the year, whilst many of the wells, being impregnated by drainage from burial-grounds or sewers, yield water of a decidedly pernicious quality. Artesian wells, that is, wells sunk through the London clay into the chalk, produce excellent water; but only of limited quantity, the supply failing in dry weather, and being seriously affected if a deeper well be sunk in the neighbourhood: indeed, it appears certain, that if all the water lying in the chalk of the London basin could be brought to the surface, it would fall short in quantity of that required. The question which the author proposes is, how to obtain a sufficient supply through the medium of these wells; and his plan is as follows:—At a given distance from the Thames, on each side thereof, to sink down to the chalk a series of shafts, and form a short canal from the mouth of each shaft to the bank of the river, at such a level that when the tide is at a given height, the water will flow into the shafts; whereby an immense supply would, twice a day, be given to the chalk basin. Other shafts are to be sunk at small distances from the former ones, up which the filtered water would rise, as into inverted syphons, till near the level of the Thames; and from these ascending-shafts it should be distributed by steam-power. By this plan, the chalk stratum of the London Basin, extending from Highgate to Forest Hill, would be converted into a large filter. A shaft of the diameter of those of the Thames Tunnel would probably filter a quantity of water equal to that supplied by the New River. The shafts might be converted into preparatory filter-beds by filling them with sand and gravel. The author considers that the water being thus quickly filtered through the chalk, would not become so impregnated with lime as the water usually got from Artesian wells, which has lain in it for a length of time. This plan would allow of the existing mains, pipes, &c., of the water companies being used as before.

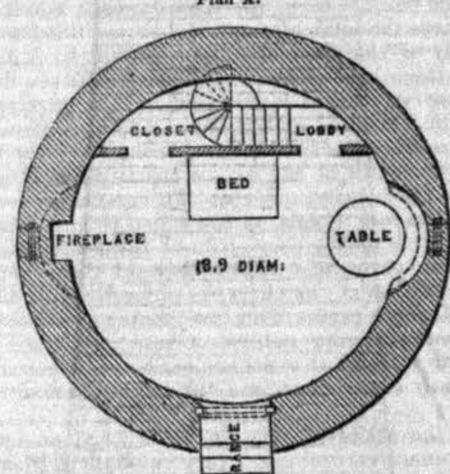
The author stated, as an example of the absorbing properties of the chalk, that farmers, on or near the outcrop of the chalk, frequently sunk shallow wells, which served as drains and removed a large portion of useless surface water.

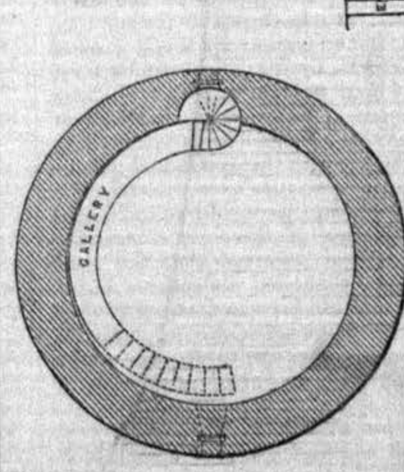
It was stated that the water from the Artesian wells contains three times the amount of chemical impurities of any of the waters from the streams around London: the water of the Lea contains twelve grains of lime to the gallon; but the water from Artesian wells, in addition to lime, contains sulphate and muriate of soda, &c.

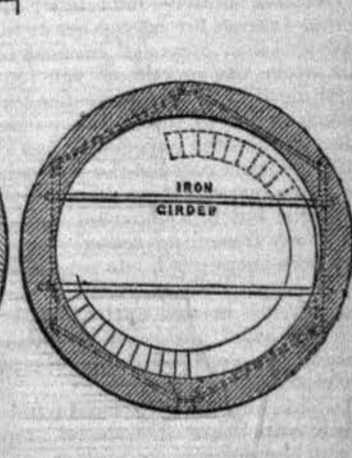
THE BARROW MONUMENT, ULVERSTON.

This interesting testimonial to the late Sir John Barrow has just been commenced in the immediate neighbourhood of his birthplace—Dragley Beck, near Ulverston. A public subscription was raised for the purpose, amounting to upwards of 1000*l*., and the whole is erected under the auspices of the Board of Admiralty. The type of the memorial, as will be seen in the elevation and section given in our next page, is to be found in the well-known Eddystone Lighthouse, and, like that stately beacon, it will be a highly serviceable sea-mark in the difficult and dangerous navigation of Morecambe Bay. The plan of the building is circular, about 45 ft. diameter at the base, and tapering gracefully to a lantern, 12 feet diameter, and finished by a dome. The extreme height is 100 feet. For the substantial walling the material used is known as "Trap" stone; the facings, &c. of Birkrigg limestone. A seat will encircle the foot of the tower at the exterior, and the various levels of the interior will be reached by a geometrical staircase. The highest room is intended for an observatory, and will be so constructed that it may at any time be easily converted into a lighthouse. The first stone was laid on the 15th inst. by Sir George Barrow (of the Admiralty), assisted by his brother, Mr. John Barrow, in the presence of a vast concourse of spectators. The design and superintendence are committed to Mr. Andrew Trimen, architect, of the Adelphi; and the contractors are Messrs. Smith and Appleford, also of London.

Plan A.



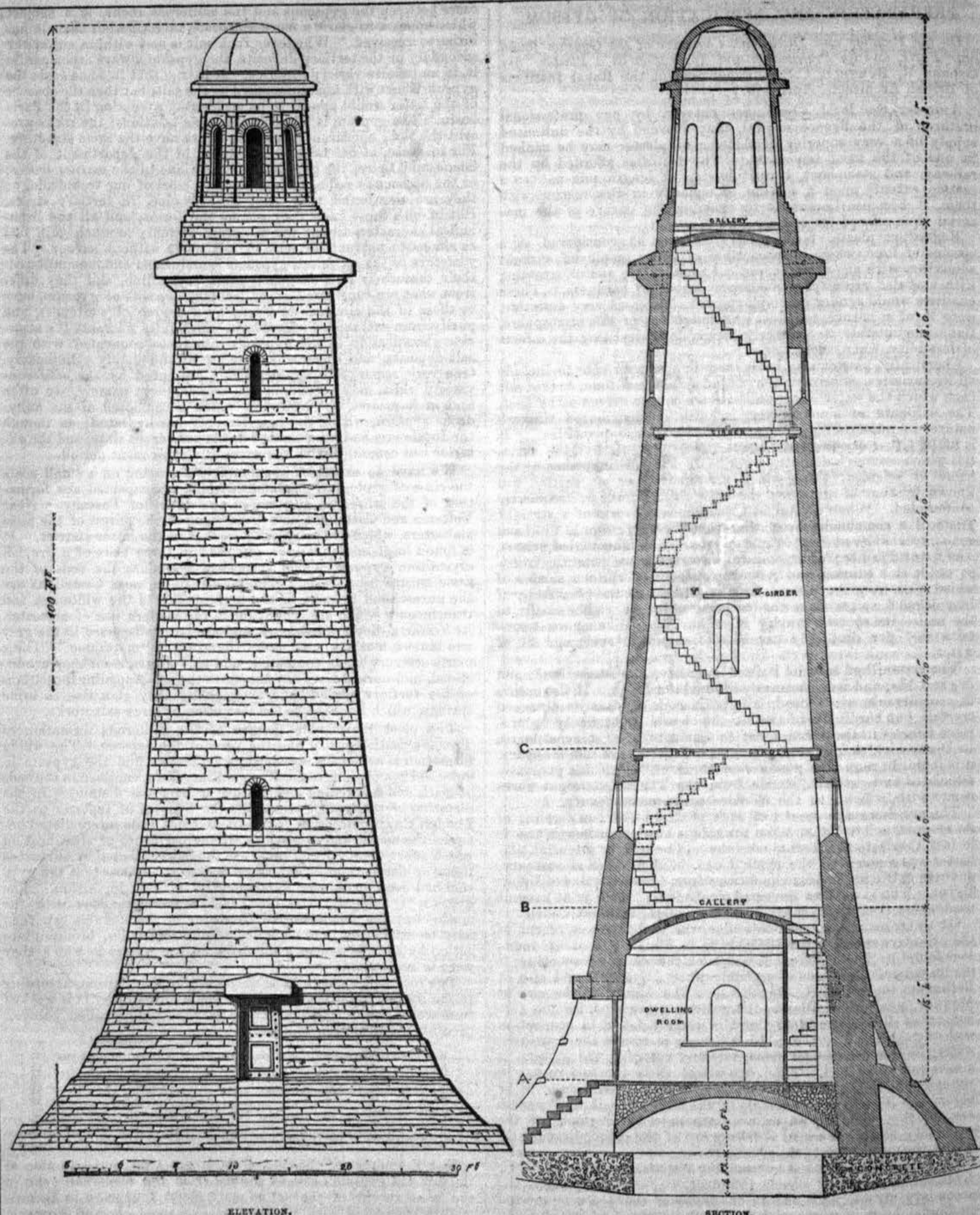




Plan B. Plan C.

From the elevated position of the monument it will be conspicuous on all sides for a considerable distance. It has been ascertained that an unobstructed view of one of the finest bays in Europe, the Bay of Morecambe, from Green Odd round to the entrance of the Duddon, will be gained from the observatory of the Tower, with the exception of only about 1200 yards, which will be obscured by the highest point of Birkrigg. It also overlooks the Isle of Man, and the coast of Wales from Liverpool to Anglesea.

The ceremony was attended by every token of rejoicing; and a sumptuous dinner closed the festivities of the occasion.



THE BARROW MONUMENT, ULVERSTON, LANCASHIRE.

MR. ANDREW TRIMEN, ARCHITECT, LONDON.

PREPARATION AND APPLICATION OF GYPSUM.

On the Peculiar and Distinctive Character of the Gypsum found near Paris, and its Preparation and Application as a Plaster. By GEORGE R. BURNELL, C.E.—(Paper read at the Royal Institute of British Architects, April 8th.)

AMONGST the local advantages enjoyed by our professional brethren of the French capital, that afforded by the unlimited supply of a very superior description of plaster may be ranked as one of the most important. The facilities afforded by the railway, and steamboat, transit having at length put us (to a certain extent) upon a footing of equality in this matter with them, it becomes important to examine the nature of the material thus offered for our use.

Regarding plaster mechanically, it may be considered as a species of lime, which is susceptible of being employed without admixture with any other ingredient than water; and of attaining with singular rapidity, a moderate degree of hardness. These qualities would render its employment in all cases very desirable, were it of a nature to resist the influences of the atmosphere. But unfortunately it is utterly incapable of resisting the effects of humidity, when used alone.

Chemically, plaster may be defined, in a manner able to include all its varieties, as being a dehydrised sulphate of lime, or that salt from which the water of crystallisation has been driven off by heat. The sulphate of lime is very plentifully distributed through nature, in numerous positions, and in very large quantities. "It is found either crystallised, fibrous, massive, or earthy: the varieties which assume a definite crystallisation are distinguished by the name of selenite; those which are amorphous, or earthy, are known by that of gypsum: the names are, however, frequently confounded. When crystallised it assumes the form of a straight prism of a rhomboidal base, whose angles vary from 113° 5′ and 60° 3′, to 113° 3′, and 66° 52′, terminated by oblique angled prisms. The natural joints are very visible; the crystals are generally transparent with a shining pearly lustre; and are of various shades of white, yellow, grey, brown, red, or violet colour. Sulphate of lime ismuch softer than the carbonate, and it yields easily to the nail. Its specific gravity is about 2·31. When pure it contains 32·7 per cent. of lime; 46·3 of sulphuric acid; and 21 of water.

The crystallised selenite is found at Alston, in Cumberland, and in great abundance at Shotover-hill, in Oxfordshire. It also occurs in considerable quantities in all argillaceous deposits, in detached crystals, but hardly ever in veins. It is said occasionally to traverse fissures in the primary rocks accompanied by mineral veins. In Derbyshire, and some of the mines of the Hartz and Hungary, it is found in remarkably long slender fibres, which are generally associated and curved. At Matlock, a variety with straight fibres is met with, which is of remarkable brilliance and beauty.

The massive sulphate of lime is termed alabaster, on account of its resemblance to the material properly so called, although this is in fact a stalactical carbonate of lime. The real, or oriential, alabaster was much used by the ancients for the purpose of statuary, and was extracted in large quantities from the mountains of Upper Egypt. The variety of the sulphate of lime, which is at present used under that name, is principally obtained at Mount Cenis.

Granular massive gypsum is found overlying the most recent of the primitive rocks, and sometimes it is said, enclosed by them. It is found in Siberia mingled with mica, felspar, and serpentine; it occurs between two beds of gneiss near St. Gothard, and also at Bellinzina in the Alps, and also near the Mount Cenis; and at Moutier, near Mont Blanc. It generally accompanies the carbonate of lime formations; and is largely found in connection with the saliferous system. In Scotland, it covers the transition rocks; in Derbyshire and in the midland counties, the gypsum is also found in connection with, or contiguous to the salt rocks; in the north of Spain, and in Tuscany, the same co-relation is to be observed. The gypseous and saliferous formations of the Pyrenees are, equally with the analagous formations in England, of the secondary series; those of Tuscany are of the older pliocene era; whilst the most important deposits as the sulphate of lime, namely, those near Paris, are of the eocene formations, according to Sir C. Lyell's classification. It is, however, to be observed that the secondary strata, with which the gypseous rocks are connected in England, are of the early secondary divisions; whilst in Spain they are only found associated with the chalk, or occasionally with a formation similar to the tertiary sub-Appenine rocks.

The intimate connection which exists in the great majority of cases between the gypseous and the saliferous rocks, is a subject which appears to merit a more elaborate investigation than it has hitherto received. Whenever rock salt is met with, in either the secondary or the tertiary deposits, the gypsum always accompanies it, in an infinite variety of forms. It is true that in some cases the gypsum is met with unaccompanied by the salt; but then the absence of the latter would appear to be accidental, excepting in the Paris basin. The gypsum is found in the same positions; the rocks present the same appearance; and the strata have the same structure. For instance, at St. Léger sur Dhune, in the department of the Soane and Loire, the gypsum is found alone in the *marnes irisées*, or the upper new red sandstone and red marl of our technicology; they are also found near Aix, in Provence, in tertiary strata. But in both these cases they assume the forms, and all the lithological characteristics of the saliferous system; so much so in fact as almost to warrant the term of salt rocks without savour. • The structure of the saliferous gypsums is undulated and mammillated; their texture is fine, compact, often crystalline, and they differ from what are considered as sedimentary deposits of gypsum, such as those of the environs of Paris, by a degree of whiteness, and purity from extraneous ingredients, which fully warrants the separate classification of the gypsums into those connected with the salt deposits, and those which are purely and simply sedimentary. One very remarkable appearance is presented by the saliferous variety which never occurs in the sedimentary; namely, we often find in it masses, the centre of which is composed of the anhydrous gypsum, whilst the exterior only has hydrated; as though the total mass had been formed in the anhydrous state, and the exterior had combined with the water at a subsequent period.

We have an excellent opportunity of tracing on a small scale the class of geological phenomena which accompanied the formation of the saliferous gypsum in the duchy of Tuscany. Near Volterra and Castellana, are found some of the purest of the false alabasters, which are principally worked at the latter district. It is found in glandular masses, enclosed in three beds of a greyish crystalline gypsum, which somewhat resembles the beds of the same nature near Paris. The masses found near Castellana are the purest, and present in the highest degree the whiteness and translucence which are sought for in the modern use of alabaster. At Volterra they are less pure, and are found dispersed in the grey and blueish marls, known under the name of "mattajone." These marls are very much contorted; and at Volterra itself they are inclined, and upraised. They belong to the sub-Appenine formations of the tertiary period; and occasionally they give rise to brine springs, which have led to the formation of large salt works.

The most remarkable feature of the saliferous formation of Tuscany is the purity and the mass of the gypsum. The whole formation is evidently stratified; whether we find the gypsum in detached rounded masses, with mamillary faces, enclosed in the beds of marl, and succeeding one another at irregular distances, in the direction of the stratification, like the nodules of septaria in the London clay; or whether it constitute thick beds intercallated between the marls, and exposed to all the accidents of stratification which affect them. In no cases are the marls affected by purturbations, or alternations, which might lead us to suppose that the gypsum had been introduced subsequently to their deposition. The gypsum is evidently stratified, and contemporaneous with the mattajone; the amygdalordal character of the nodules can then only be attributed to the affinity of the molecules, brought into action by specific causes which affected the waters in which they were in suspension.

The rock salt appears to be disposed like the gypsum, according to the lines of stratification of the whole formation. It is worked from wells; one of which, executed near the factory called "Moye," presents the following beds:—

		ft.	in.
1. Blue marl, containing nodules of alabaster, which is about (in thickness)		144	4
2. Rock salt		15	7
3. Marl, with gypsum		19	7½
4. Saliferous marl, about (in thickness)		14	1
5. Blue marl	„	37	5
6. Saliferous marl	„	29	6
7. Gypseous marl	„	26	0
8. Rock salt, (greatest deposit)	„	41	0
9. Blue marls	„	166	8

Now the nature of the causes which led to this intercallation of the salt and gypsum between the strata of this formation (one of the most recent of the saliferous deposits), appears to be intimately connected with the existence of the lagoni of Tuscany, which are the last traces of a series of phenomena acting, in all probability, with much greater energy at the epoch of the deposition of the tertiary strata. These lagoni are eruptions of aqueous

vapour at a temperature of 105 to 120 centrigrade. They burst forth with violence from fissures in the ground, and rise in white columns from 30 to 66 feet from the earth. They are accompanied by a strong odour of sulphuretted hydrogen; they alter the rocks they approach, and deposit in them crystalline or concreted gypsum, occasionally mixed with sulphur and boracic acid.

The lagoni are found in groups of from ten to thirty, nearly in a straight line extending from the Mount Cerboli, Castel Nuovo, and Monte Rotondo; as though they followed the direction of a fault, or dyke whose length is from 20 to 25 miles. The boracic acid they contain is extracted by means of the heat of the lagoni themselves, which are made to evaporate the waters drawn into basins for that purpose. But the most interesting geological fact connected with them is the influence their vapours appear to have in the formation of the sulphate of lime; which accumulates in small crystals, or in crystalline masses in the marls, and the calcarceous strata they traverse.

If such lagoni had acted upon the gulfs or the lakes of salt water, of the tertiary period, it is easy to account for the alternations of the gypsum and the rock salt in the sedimentary deposits of that period. The gypsum, whether crystalline, in small beds, in mamillary, or botryoidal nodules, which are disseminated in the marl beds, would naturally result from the phenomena of affinity of which we find instances in almost every formation. The gypseous strata we may consider as representing the epochs of activity of the vapours, and of the disturbance of the waters; the saliferous strata would correspond with the epochs of tranquility, during which the evaporating powers of the jets exercised alone their influence. The presence of the borates of magnesia (which are sufficiently common in gypsums) may be explained also by the nature of the lagoni in actiivity at the present day.

The gypseous formation of Paris differs from all those we have hitherto considered on many accounts. Geologically a very marked distinction is to be made, inasmuch as from the manner of its formation, its stratification, and the shells it contains, we are led to believe that it was produced by mechanical deposition rather than by chemical separation, like the other formations. The rocks now to be examined form a portion of the immense tertiary deposits which fill a depression in the chalk, called, from the fact of Paris occupying its centre, the Paris basin. An adventitious interest is communicated to this formation from the fact of its having led M. M. Cuvier and Brogniart to propound the doctrine of the superior importance of the study of organic remains, to that of the lithological character of a deposit; a doctrine, it is true, previously propounded by our countryman Smith, but the superior knowledge of the French geologists in comparative anatomy, and conchology, placed the question beyond doubt. The Paris basin was the first which was distinctly classed as a tertiary formation, and the announcement of this classification gave rise to the researches which led to the discovery of similar deposits in many other parts of Europe. There is also a chemical difference between the Paris gypsum and any of the saliferous gypsums hitherto noticed, viz.—that it contains as much as 12 per cent. of carbonate of lime in combination. This appears to communicate to it the much superior power it possesses of resisting atmospheric change. Another difference lies in the mechanical structure, for the Paris gypsum is the hardest known, except perhaps that found near Girgenti, in Sicily, which, according to Rondelet, a most conscientious authority, is still harder. We do not, however, possess any details on this subject.

The gypseous deposits near Paris form a very distinct and easily identified group, or subdivision, which comprehends (at the same time as the gypsum) alternating beds of marl, either calcareous or argillaceous. These beds follow an order precisely identical throughout the whole district, from the neighbourhood of Meaux to Meulan. Some beds are absent in particular cantons; but those which are still to be met with occupy the same relative positions.

The gypsum immediately overlies the calcareous beds Cuvier designated as the "calcaire marin;" and their appearance in the landscape in the neighbourhood of Paris is very remarkable, even in a picturesque point of view. They cap the hills of the older and harder formations; and appear to have suffered more severely from the denuding effects of the cataclasms which gave rise to the existing valleys, than the subjacent rocks. They thus form, as it were, a second range of hills (sometimes conical, as at Montmartre, Les Buttes Dorgemont; or elongated, as at Chaumont and Belleville, Triel, &c.) superposed on a first series of hills, bearing all the characteristic marks of the calcareous ranges.

We find at Montmartre and at Belleville, where the formation exists in the most perfect development, that there are three masses of gypsum of various thicknesses. The lowest mass, situated immediately upon the "calcaire marin" is composed of beds of gypsum of feeble thickness, containing a large proportion of selenitous, or crystallised gypsum, and alternating with beds of calcareous marl, of a very solid character, or with argillaceous marls in very thin flakes. Sometimes a deep bed of white fresh-water marl is interposed between the gypsum and the upper courses of the "calcaire marin." The number of the beds of gypsum in the lowest mass is five; their total thickness is not more than 7 ft. 7 in. This mass is seldom worked; for the double reason, that its extraction is very difficult, and the quality of the plaster it yields is decidedly inferior to that of the upper masses. But it is to be borne in mind, that the thickness and the number of the beds in the lowest mass are very variable. Those quoted above are obtained from the quarries called "L'Amerique," at Belleville; at Montmartre the total thickness of the beds of gypsum and the marls is from thirty-three to thirty-six feet, measuring from the upper bed of gypsum to the bed of white calcareous marl. There is, however, something exceptional in the nature of this third mass at Montmartre, inasmuch as it has never been observed to pass under the others, and it occurs in a detached hillock, rather towards the east. Its beds are not horizontal, but decidedly inclined towards the south-west.

The second and third masses are separated by a set of beds of marl, whose thickness is about five feet. Like the third mass, it is composed of a series of beds of gypsum, intercallated with marl in variable thicknesses, and without definite order; that is to say, that the marl beds are wanting in some localities, whilst they are very numerous and powerful in others. The greatest thickness which the second mass exhibits is met with in the quarries at Montmartre, where it sometimes attains as much as 33 feet. At Belleville, the height is, however, rarely more than 19ft. 6in.; and it affords eight workable and useful beds: the irregularities in the thickness appear to be, however, more owing to the beds of marl than to those of gypsum, which present a very striking uniformity. The second mass yields a stone which makes excellent plaster. One bed in particular, found at Belleville, and called by the quarrymen "le gros banc," three feet in thickness, is often set aside for the purpose of making plaster for the exclusive use of statuaries or artists.

The first mass is the most important, and also the most widely distributed. The lower masses are wanting in many localities, as at Triel, where the first mass rests immediately upon the marls and clays interposed between the first and second masses in Montmartre and Belleville. At Montmorency there are two masses; but in all cases the relative superiority of the first mass, both in quantity and freedom from mixture of the marl beds, is very remarkable. In some cases, as at Dammartin and Montmorency, this formation occurs immediately under the vegetable soil. At others, as at Belleville and at Montmartre, it is covered by a series of beds of sands, clays, argillaceous and calcareous marls, which attain as much as from 110 to 120 feet in thickness. A somewhat similar set of beds of marls and clays forms the floor, separating the first from the second masses of gypsum; its thickness is variable, but may be taken as being about 10 feet on the average.

The upper beds of the first mass are strongly impregnated with marl, and this latter substance even intercallates with the gypsum with sufficient regularity to enable us to follow the respective strata over great distances. They are soft; the workmen group them under the name of "les chiens;" and they yield a very inferior plaster if burnt alone. Their united thickness is about 5ft. 6in.; and they are six in number, in some of the quarries at least, never being fewer than five. The intermediate beds whose number and thickness is the most exposed to variations, are divided naturally into large many-sided prisms, which have procured for them the name of "les hauts piliers" among the quarrymen. Their united thickness is about 35 feet; the quality of the stone they yield differs somewhat, and care is requisite in the burning to secure a plaster of uniform quality. The bed called "la corraie," about 2 ft. 9 in. thick, is very hard, and it requires to be mixed with the softer beds to make a saleable article. Two others, "les battaillon" and "les rousses," are reserved for the special use of statuaries. The lowest beds of this mass contain much silex, which even at times seems to shade off as it were into the gypsum, without our being enabled to say precisely where the one begins or the other ends. The plaster made from them is of rather an inferior quality compared with that obtained from the intermediate beds.

The lowest mass contains at times, especially in the associated marls, marine fossils, and large crystals of selenitic gypsum. The

second mass contains fossil remains of fish, without any other traces of animal life; the marls also contain at times kidney-shaped nodules of the sulphate of strontian. In the first mass are found the numerous remains of extinct birds, animals, plants, and shells, which render these formations so celebrated in a geological point of view. On the north of Paris they are preserved in the gypsum itself, and they retain a considerable degree of consistence, being only surrounded by a thin coat of marl. On the south of Paris, however, they are often found in the marl beds, and are then very friable. The fossils of mammalia are exclusively confined to the first mass, and in no instance are they met with in any of the lower divisions. In the lowest, fossil trees have been found, and fresh-water shells in remarkable abundance. Cuvier gives a list of fourteen extinct species of mammalia, three or four birds, three reptiles, and three or four species of fish: Lyell gives a much greater number.

Now, the immense development of these gypseous formations, and the total absence of any traces of salt throughout the whole extent, as well as the nature of the fossils they enclose, lead us to believe that they must have been deposited under different circumstances from those which gave rise to the saliferous gypsums. An examination of the phenomena connected with their probable geological history would lead us into discussions which might be considered out of place here. Those who may be desirous of studying the question more thoroughly are referred to Sir C. Lyell's 'Principles of Geology.' In the chapter upon the eocene formations of the Paris basin the question is fully treated, with the elegance, eloquence, the power of grouping facts, of adorning details, which in Sir C. Lyell's case gives to science all the charm of romance. Suffice it to say, that the present theory of geologists leads them to regard the great mass of gypsum, in this district, "as a purely fresh water deposit, produced by a river whose waters were highly charged with the sulphate of lime, somewhat like La Frume Salso, in Sicily."

The method of raising the plaster stone differs, of course, with the circumstances under which it is found; that is to say, it is sometimes got by means of open cuttings, or by galleries, worked either from the hill side or by wells. The peculiarly abrupt manner in which the spurs of gypsum terminate upon the heights round Paris, renders the mode of working from galleries driven into the hill face the most usual. At Montmartre, Triel, and Belleville, the quarries are all worked in that manner. The regulation of the quarries is, like everything else in France, subject to a very scientific and inquisitorial supervision on the part of the government. The service of the mines is under the control of a special body of engineers, called "Les Ingenieurs des Mines," who are charged to insure the public safety and the lives of the workmen, which might otherwise be compromised by the mining operations; to defend the rights of the state to the discovery of the precious metals; and subsidiarily to ascertain all geological facts which might influence the national wealth. The consequence of this organisation is, that the statistics of French geology, if such a term be allowed, are classified in the most wonderful manner; an instance of which, by the way, is to be found in the geological map and explanation published under the direction of M. Elie de Beaumont. However, quarries in open cutting are worked by the proprietors of the land, without any control on the part of the engineers of the mines; and they are simply under the control of the police. When they are under ground, the quarries are under the special control of the engineers, and the principles which regulate their working are those laid down by a decree of Napoleon's, dated March 2nd, 1813. Rigorously, the stone or gypsum quarries ought to be worked with something like the regularity of a chessboard; the galleries being 15 metres, or about 50 feet wide, with piers at equal distances of 10 metres, or 33 feet square. In practice this mathematical precision is neglected, but it may be considered as the average manner of working. The quarry-cap of the gypsum does not admit of being left with so wide a bearing as 50 feet, as might naturally be supposed. A small heading is then driven in the bed, called the "souchet," by a man lying flat on his back, for the bed is only 1 ft. 8 in. deep, who leaves the upper bed, "le banc be grand abattage," unsupported in this manner, for a width of 8 feet. For this very painful work the miner, called in this case the "caveur," is paid at about the rate of 1s. per foot forward; he finding his own picks, the proprietor the candles. The other beds are then raised by wedges, bars, or gunpowder, as may be required. A good quarryman can raise about 9 yards cube per day, of the first mass, and about 5¾ yards of the two lower masses, when the workings are in gallery.

We have before seen that the quality of the gypsum is not the same through the whole thickness of the different masses. Great care is then required in mixing the different sorts of stone, so as to secure an uniformity in the plaster obtained by the burning. Some of the beds are reserved for special uses; the hard beds, in the remaining portions, require to be mixed with the softer ones. As might naturally be expected this variety introduces a complication in the manufacture, which frequently gives rise to improper fabrication, and opens the door to much fraud. Indeed, the fabrication of plaster near Paris, still more in the departments, is liable to all the reproaches we so unsparingly address to our own cement manufactures. Such must always be the result of unlimited competition, and as long as price is made of more importance than quality such they will remain.

The mode of burning usually adopted is very rude. It consists simply in building, within three walls, covered with a rough fixed roof, a series of arches 1 ft. 8 in. wide by 2 ft. 4 in. high, with piers formed of gypseous stones, as are also the arches. These are then filled up to a height of 13 feet with stones, so arranged that the largest are at the bottom, the smallest at the top. The arches are filled in with fire-wood, which is set light to, and the fire kept up so as to maintain the baking for twenty-four hours. The dimensions of these kilns are such as to enable them to hold from seventy to seventy-five tons. In some of the quarries a more rational style of burning is adopted, which consists in passing the already pulverised stone through cylinders, which revolve in an open fire. I have, also, in one of Mr. Weale's Treatises, mentioned an application of over-heated steam to the same purpose; but the inquiries I made in Paris, about a month since, lead me to believe that it has not yet been fairly tried.

Indeed, there is always a difficulty in introducing any new process in the ordinary arts of life, such, for instance, as the one which meets us on the threshold in the use of the French plaster. Near Paris, the workmen have always been accustomed to employ plaster burnt in immediate contact with the wood. In that process the brees become necessarily mingled with it, and we find now that the men have come to consider the grey colour they communicate as an indication of a superior quality. The Paris workmen, in fact, do precisely the reverse to what our workmen do; upon the same principle, nevertheless, viz.—from an irreflective habit. They dislike a white plaster; we attach far too much importance to it. Truth, as in most cases, lies in the mean. The absence of the brees certainly does not diminish the value of the plaster; the extreme whiteness we contend for in London is for the most part obtained by the use of a softer description of stone, or by the admixture of some extraneous ingredient.

The operation of burning the plaster stone, is, after all, only effected for the purpose of dehydrising, or driving off the water of crystallisation from the gypsum. Before this is done, the stone is hard; afterwards, it becomes pulverulent and floury. The *rationale* of its use is, simply to present such a quantity of water as is necessary to restore it to the original state, when it resumes its natural hardness, with a commencement of a confused crystallisation. Now this action may be, and is, carried on irrespective of colour; that is to say, at least, the presence of the wood ashes, which gives rise to the grey tint the Paris workmen require, does not affect the combination with the water. Our own very white plasters owe their beautiful colour to the absence of the carbonates of lime, or the marls, which, in fact, communicate the very superior qualities to the stones yielding plaster less purely white.

To secure a good quality of plaster it is advisable to apply a moderate heat in the beginning, which is to be augmented gradually When the plaster is not sufficiently burned, it becomes dry and sandy; in this state it does not set with any degree of hardness. When it is overburnt, it also loses its adhesive properties; it ceases to have what the workmen call "de l'amour;" it will not cling to the fingers, nor has it the rich unctuous quality which characterises the well-burnt plaster. As soon as it is burnt, it should be ground, and employed as soon as possible after the manipulation is completed.

Fourcroy believed that the carbonate of lime contained in the Paris gypsum, became converted into quick lime during the burning; and that the superiority of that plaster was to be attributed to that change. Guy Lussac, however, held that the carbonate could not be affected by the moderate heat called into action (it is only absolutely required to be about 270 Fah.) He attributes the superiority rather to the great hardness of the stone; and really there does not appear to be any other explanation. We are aware that, *cæteris paribus*, the law exists, that the limestones yield limes producing mortars whose degree of hardness, when set, is in the ratio of the hardness of the stone. Nor does there appear to

be any reason why the gypsums should differ from the carbonate of lime in this respect. Indeed, we find that the law holds good with the English gypsums, for the Derby stone makes a stronger plaster than that of Newark, just as it is harder than the latter. Dumas agrees with Guy Lussac, in supposing that no other chemical action takes place with the gypsum, than the evolution of its water of crystallisation.

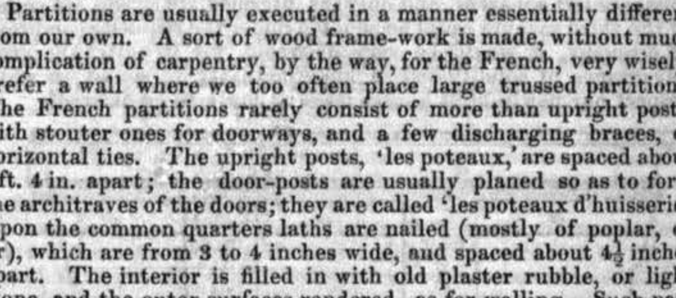
In Paris, the mode of using plaster is to employ it pure and free from mixture. The very low price at which it is sold, and the comparatively high price of sand, dispense with the motives of economy which render mixtures almost indispensable in our case. The town of Paris pays for its municipal works, at the rate of 12s. 9½d. per ton of plaster, whereas it cannot yet be had in London for less than about 40s. per ton. Whilst the practice in France is to use plaster pure, I am disposed to think that the mixture of sand, so far from being prejudicial, is even desirable, if confined within reasonable limits. We find that in reassuming the state of hydrated sulphate of lime, the plaster goes through an imperfect crystallisation; and this action is accompanied by a singular re-arrangement of the molecules. This causes the plaster to swell when used alone, and to such an extent, that it is impossible even to finish a ceiling close up to a wall at once. Now the introduction of a body so full of inequalities as the coarse, sharp sands, must afford room for the free action of this expansion; and, at the same time, the facettes of the sand must offer, as is were, nuclei, which cannot but be favourable to the crystallisation. It is, doubtlessly, on these principles that we can explain the superiority of the plaster containing the wood brees, which does become harder than the purer plasters, if used alone. Too large a proportion of sand should be avoided; but very fair work can be executed even with a mixture in the proportions of two of sand and one of plaster. Under any circumstances, the finishing coat should be pure. Subsequent experience will decide, whether the use of two materials of this kind does not expose the work to unequal contractions, likely to cause fissures, or cracks.

The plaster made near Paris sets with a rapidity very much greater than any material we are accustomed to for plastering purposes; and, for very large uniform surfaces, perhaps this is a difficulty. The workmen have not the time to work the floating coats with the mathematical correctness we usually exact in our country. But, to a certain extent, this objection may be obviated, by slight differences in the mode of preparing the plaster, or by altering the quantity of water in proportion to the positions in which the material is required to be used. Thus, if all the strength of the plaster is needed, the smallest quantity of water is introduced; about as much in bulk as the plaster itself occupied, This is called by the workmen, "gâcher serre" (stiff guaged). When it is necessary to work and re-work the face, as in setting coats, more water is added, or the plaster is said to be "gaché clair" (guaged thin). Habit alone can fix the precise proportions, for it is impossible to arrive constantly at the same results in the burning. For the very finest works, the workmen make what they call a "coulis;" this is run in, in a semi-fluid state. Plaster which has been thus treated, with an excess of water, does not acquire the tenacity, nor the hardness of that treated in such a way as only to present to it the water of crystallisation.

The extraordinary forces of adherence, &c., of the Paris plaster, enables the work on ceilings or partitions to be executed with far less expense of lathing than similar works executed with our lime and hair. Rondelet made experiments to ascertain the limits of these forces, and he obtained the following results:—A parallelopipedon of plaster, with a base measuring 1 in each way, supported a weight of 76lb., acting so as to tear it asunder; this he called the force of adhesion. Similar figures resisted a crushing weight of 722lb.; so that the ratio of the resistance of plaster to an effort of traction, compared to one of extension, is as 1·9½. Rondelet found that there was a sensible difference in the manner in which plaster adhered to brick or stone, from the action of mortar under similar circumstances. For, when cubes, joined by the respective materials, were subjected to forces tending to tear them asunder, the mortar broke through the centre of the joint, leaving particles attached to the upper and under surfaces; the plaster, on the contrary, left the surfaces perfectly clean. In new works, the plaster adheres to other materials, with about half the force necessary to tear it asunder: mortar, for several years at least, only attains one-third of the same force. This ratio does not continue; for, after ten or twelve years, the plaster loses its strength, whilst, at the same epoch, we find the adhesion of the mortar to other substances to be equal to the force of adhesion of the cubes themselves. The subsequent ratios are in inverse progression; mortar always hardens *by time—plaster loses strength.* As these remarks *only apply* to *its use as a mortar externally, it should never be employed permanently for such positions; internally the loss of strength is* not so rapid, for it depends upon the absorption of moisture from the atmosphere. For temporary works; for internal works, requiring great rapidity of execution, however, the use of Paris plaste is invaluable.

The usual practice in Paris (as I had the honour of observing in a paper I read last year), is to execute the work intended to be plastered with rubble stone, set in plaster mortar. If possible, the principal elevations are executed in ashlar; externally, plaster is never used if it can be avoided, for its use requires care and numerous precautions. Firstly, the plaster coat must be entirely out of the ground; it must be removed from all weatherings, where the capillary action would allow the absorption of water; the upper surfaces must be covered with zinc, or other metal; and, if it be expected to stand for many years, the whole must be painted. When, however, plaster is to be applied on walls, externally or internally, the course followed is to clear out the joints of the masonry, and to wet the surface. Plaster, gauged stiff, is laid on with a broom, or in any similar expeditious manner, and it is brought to a tolerably uniform face by use of the trowel. This is called 'faire le crepi,' a term equivalent to our "rendering." The floating coat, or 'l'enduit,' is applied by the trowel, and dressed off with a rule, in somewhat a similar manner to the system followed by our own workmen; but it is in the execution of this work that the greatest difficulty arises, from the rapidity with which the plaster sets. The stuff is gauged thin, but not sufficiently so to allow much manipulation. When the face is floated, as described, the plasterer passes over the surface with a sort of toothed trowel, called 'la truelle bretelée;' using, firstly, the toothed side, to remove any asperities, and finishing with the knife edge on the other. A thin setting coat is lastly added, to stop up all the pores or inequalities. The time required to complete such plastering on wall is very short compared with what we are accustomed to. The floating coat may be applied within four days of the rendering, under favourable conditions; and the whole work easily completed in a week.

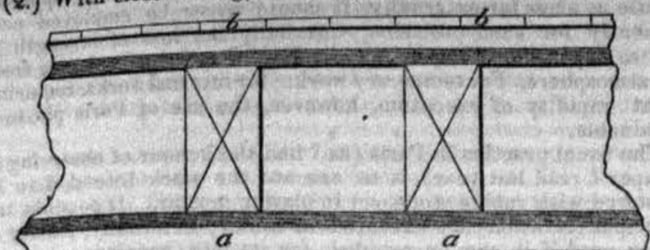
Partitions are usually executed in a manner essentially different from our own. A sort of wood frame-work is made, without much complication of carpentry, by the way, for the French, very wisely, prefer a wall where we too often place large trussed partitions. The French partitions rarely consist of more than upright posts, with stouter ones for doorways, and a few discharging braces, or horizontal ties. The upright posts, 'les poteaux,' are spaced about 1 ft. 4 in. apart; the door-posts are usually planed so as to form the architraves of the doors; they are called 'les poteaux d'huisserie.' Upon the common quarters laths are nailed (mostly of poplar, or fir), which are from 3 to 4 inches wide, and spaced about 4½ inches apart. The interior is filled in with old plaster rubble, or light stone, and the outer surfaces rendered, as for walling. Such partitions answer admirably for the purposes of keeping out sound, and are tolerably light. From the immense quantities of plaster rubble to be met with in Paris, they are also, comparatively speaking, economical, Close lathing is very rarely executed; nor, in fact, do the oak laths used in France allow such work to be well done. Some masons in Paris use a sort of tile, cast beforehand purposely for this use, and made of plaster. This system is not so solid as the usual one of only employing rubble, for the plaster does not adhere so well to the smooth faces of the tiles; but it avoids a very considerable amount of humidity.



(1) *Hourdé Plein.*

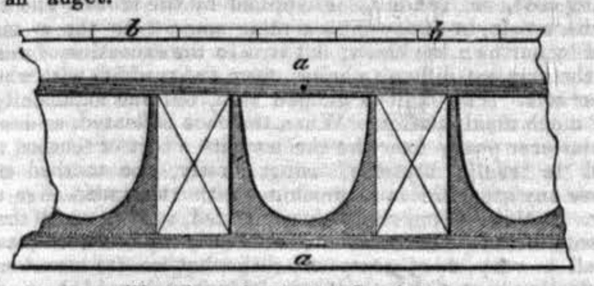
Ceilings are executed in several manners.—(1.) The space between the joists is filled in solid, with plaster, or stone, rubble carried on rather wide laths underneath; the lower surface is then rendered like a wall would be, and a bed is formed on the top to receive the tiles, or sleeper joists and flooring are added. This is said to be 'hourdé plein.'

(2.) With close lathing, as in England, 'à lattis jointif.'



(2) *A Lattis Jointif.*

(3.) The third manner, and the one most usually adopted, because it binds the joists together the most effectually, without loading them unnecessarily, consists in lathing the underside of the joists at distances of about $3\frac{1}{2}$ inches from centre to centre. A species of flat centering is then placed under them, and a coat of plaster of about $1\frac{1}{4}$ to $1\frac{1}{2}$ inch is laid over the laths so as to stop against the boards on either side, and between them. The plaster is brought up the sides of the joists, and worked so as to leave a hollow channel. The ceiling itself is then applied below this coat, called an 'auget.'



(3) *Avec Augets, en Cannivaux.*

(4.) In the country, again, another manner is used, namely, the joists are left apparent, and only the intermediate spaces are ceiled. If the third manner could be adopted under the requisite conditions of economy, it would be very desirable, for it unites the great advantages of solidity and of impermeability to sound, in which respect our newly-built houses leave so much to be desired.

(4) *A Solives Apparentes.*

Note.—The parts shaded with parallel lines represent the laths; the blank parts *a a* represent the plaster; those marked *b b* represent the floor boards or tiles, as the case may be. No. 1 counts for the value of $1\frac{1}{4}$ times No. 2. No. 2 constitutes the unity of price for common plastering—it is called "leger." Thus, No. 1 is said to be "$1\frac{1}{2}$ leger," and paid for at that rate. No. 3 counts for "$1\frac{1}{2}$ leger." No. 4 counts also for "$1\frac{1}{2}$ leger."

Now, the proprietors of the French quarries have lately made arrangements by which the real plaster of, and from, Paris may be obtained in London at prices below those of our English plaster. Its use will, I am personally convinced, very soon supersede the barbarous mixtures of lime and hair, and all such trumpery, we have been forced to employ hitherto in its absence. A new application of any material is, however, always exposed to many risks and failures; from ignorance of its qualities, from unskilfulness in the handling, and even from the prejudices of those employed to execute the works. It may therefore be necessary to endeavour to point out the conditions requisite to ensure the successful essay of the one we are now considering.

Firstly. It is not advisable in the commonest sorts of work to allow more than two parts of sand to be mixed with one of plaster; for better works, one and one should be used. The setting coat should be of pure plaster; my own opinion is that large quantities of putty, or other preparation of the carbonate of lime, should not be used, though there does not appear to be any objection to the plaster being guaged with lime-water, which not only retards the setting, but also diminishes the expansion.

Secondly. My own experience with French workmen would lead me to say that we must not expect to be able to maintain, with a material which sets so rapidly as the plaster of Paris, surfaces so mathematically true as we do obtain in the usual system followed by our builders. In Paris, for several reasons, this exactness is not required; the rooms are smaller, it is not the fashion to have large unpannelled walls, or to use even, flat, tints. Small inequalities of surface are not, under such circumstances, of so much moment as they are to ourselves. Indeed we may form a tolerably corect idea of the comparative slovenliness with which plasterers' work is done there, from the fact that some of the workmen execute both it and the masonry on which it is applied. In all the buildings in Paris I have visited, the plastering has been executed with a carelessness which would disgust any London architect. The angles are never square, or true; the upright faces hardly ever "out of winding," or "plomb." Yet when our own more skilful workmen have overcome their prejudices, and learnt the proper use of this material, we have every reason to believe that they will make as perfectly "true" work with it as with the others. At the same time it attains in an incredibly short space of time a degree of hardness we are totally unused to, and it is accompanied by the immense advantage of only giving rise to about $\frac{3}{8}$ths of the evaporation arising from ordinary plastering. A series of very careful experiments has been made under the directions of Messrs. Piper, which proves that the cost of ordinary works need not exceed in any sensible proportion, if at all, those we call usually "render, set:" that they are strictly the same as the render, float, and set; presenting a very superior article in every respect. Mr. Piper's experiments go to show that the evaporation from the French plaster is only about in the proportions just cited. In the Spicer Street Model Lodging Houses, Messrs. Piper executed, during the last week, a room which was begun and finished in thirty hours, whilst a common lime and hair rendering coat would have required a week at least ere it would have been fit to receive the floating coat, and the whole operation would have required, properly speaking, about a month. Mr. Beck, the architect, to whom all praise is due for the merit of the buildings in the first place, and for the sagacity which led him to try the new material, can vouch for the quality of the work, and explain the means adopted to obtain so very remarkable results. Subsequent experiments must, however, be made to ascertain the best mode of finishing superior work upon plaster rendering, either by the use of Keene's Parian, or Martin's cements; for it is my own perfect conviction that the use of lime and hair will very shortly be abandoned.

Thirdly. The French plaster must never be used in any position where moisture is likely to affect it for any length of time. It is very hygrometric, and soon decays if kept moist. The prevalence of warm moisture, as for instance in cellars, also gives rise to the formation of much saltpetre; its use in such places should then be avoided. The same faculty of forming the saltpetre should, also, make us very cautious as to the nature of the sand to be mixed with the plaster.

Fourthly. If the plaster be used as a mortar, for the purpose of carrying up bricknogged partitions to be covered over immediately, for which purpose, as said before, it would be invaluable, care must be taken to prevent the expansion of the plaster from affecting the other work. It is usual, in France, to leave a small space between the wall and the partitions, in carrying them up, which is subsequently filled-in by the plastering coat. The same observation applies to floors with plaster pugging, and even to cornices with a large body of that material. In the case of the latter, it is usual to run the straight mouldings, and to execute the mitres, or returns, subsequently. The projections of the cornices, by the way, are carried out solid, with very little, if any bracketing. But we must observe, that the French architects, very wisely, do not execute such terribly heavy internal decorations as we do, and that consequently their projections are less.

In the above remarks, I have studiously avoided the questions connected with the use of plaster in iron and pottery. They would have swelled this paper, already too long, to limits far beyond your patience. It is my intention to request your consideration of them upon some subsequent evening. In the mean time, we may be allowed to congratulate ourselves upon the fact, that the abolition of the excise upon bricks and tiles will enable us to make much more complete experiments.

I may add that the parties who have made arrangements for the sale of the French plaster in London, are Messrs. Piper of Bishopsgate-street, and Messrs. J. B. White and Sons, of Millbank-street. The price at which it can now be sold, is about 2*l.* per ton at the wharves.

WATER SUPPLY FOR LIVERPOOL.

Report *of* Robert Stephenson, C.E., *on the Supply of Water to the Town of Liverpool.*

The question which has been entrusted to me for my consideration and opinion, and on which I have now to report, is the best plan to be adopted for securing an adequate supply of water to the town of Liverpool; and in opening the subject, it will probably be most convenient and intelligible to introduce a copy of the Instructions conveyed in the Minute of the Water Committee of the Town Council, which is as follows:—

"At a meeting of the Water Committee, held on Monday, the 14th of January, 1850:—

Present:—James Procter, Esq., Chairman, &c., &c., &c.

"Read a letter from Mr. Stephenson, dated the 12th inst., and addressed to the Town Clerk.

"Resolved:—That the following instructions be communicated to Mr. Stephenson, and that he be respectfully requested to meet the Committee to-morrow morning at half-past nine o'clock.

"Mr. Stephenson having been unanimously appointed the Engineer for the purposes of the resolution of the Council of the 9th of November, the desire of the Committee is, that he should inform himself upon the subject in all its bearings, by evidence, reports, or otherwise, so as to ensure that the views of all parties may be elicited before him to their satisfaction, and report his opinion to the committee fully:—

"1st. Whether a supply sufficient as regards quantity and quality for the present and prospective wants of the town and neighbourhood, including domestic, trading, and manufacturing purposes, and shipping; and for public purposes, viz.—watering and cleansing streets, flushing sewers, extinguishing fires, and supplying public baths and wash-houses—can be obtained by additional borings and tunnels, or otherwise, at the present stations, viz.—those purchased from the companies respectively, and from the Green Lane Works, now vested in the Corporation; and the cost of obtaining such sufficient supply.

"2ndly. Whether a sufficient addition to the present supply can be obtained in the locality or neighbourhood of Liverpool, as recommended by Messrs. Simpson and Newlands, or by borings, or by any other course; and the cost of obtaining and distributing the same.

"3dly. Whether such supply can be obtained by means of the Rivington Works; and the cost of obtaining and distributing the same as recommended by Mr. Hawksley.

"4thly. Under all the present circumstances of the case, what course is recommended to be pursued?

"Extracted from the Proceedings.

"William Shuttleworth.

"Town Clerk."

In entering on the matter of the above resolutions, I feel it a pleasure to acknowledge the facilities which have been afforded by Mr. Newlands, the Borough Engineer, and those acting under him, both by supplying the necessary plans and by giving every means in their power for the examination and experiments at the pumping stations: and I also gladly avail myself of the opportunity to thank all who have assisted in the inquiry, either by offering their opinions and information in the public court, or in verbal or written communications.

There can be but one opinion respecting the great importance of an abundant supply of good water to such a town as Liverpool, for whether regarded in a sanitary or commercial point of view, there is, probably, nothing more conducive to the welfare and enjoyment of a large community.

In a sanitary point of view, the necessity of a large supply of water, in combination with a good system of sewerage, is now admitted on all hands;—the disposition evinced everywhere to place at the disposal of the poorer classes much larger quantities of water, and more convenient arrangements for their constant domestic supply, and to promote the general establishment of baths and wash-houses, sufficiently exhibit the strong prevailing feeling in this respect.

In a commercial point of view, both the quantity and the quality of the water supplied are also very important; in manufactures wherein water is used for the purpose of extracting vegetable or other principles from any substance; in the preparation of tea and coffee, in the saving of soap and labour in all detersive operations, in steam-engine boilers, and in economic processes generally, pure water has long been appreciated, and would no doubt be universally used where the expense of obtaining it is not too great. And when the influence of some small superiority of situation, or of the materials found or the facilities given on any spot, and the great extent to which competition now affects the profits of manufacturers are considered, the necessity is evident for taking especial care to secure every advantage that may present itself.

To Liverpool, in particular, with its high commercial position, its large and rapidly increasing population, and its immense constructions for the purposes of trade, science, and habitation, the advantage of a copious and permanent supply of good water can scarcely be over-rated.

These prominent considerations, with many others easy to mention, have led me to approach the subject with anxiety, and to devote to it my best energies. I trust the result may prove of advantage to the town and its community.

Supply from Wells.

In my inquiry, it was clearly necessary in the first instance to ascertain correctly the quantity of water yielded by the existing wells, the influence which they exert upon each other, and the mode by which the water contained in the mass of sandstone is transmitted from one place to another.

On this last and most important point the evidence adduced before me in Court was very conflicting, some of the witnesses maintaining, that however large a quantity might be pumped from one well, little or no effect was found to be produced upon those in the vicinity; and of this several well authenticated instances were certainly adduced, but a careful consideration of the whole mass of facts leads me to believe that these cases form rather the exception than the rule; and that they are occasioned by local geological faults, partially or wholly water tight, which are known to be interspersed throughout the new red sandstone formation in the neighbourhood of Liverpool.

It appears to me, also, that the purport of the evidence offered on this part of the subject was entirely misconceived by the parties who adduced it; for, it is evident that if the sandstone was so impermeable as to prevent one well influencing another at a moderate distance, it would be exceedingly difficult, if not absolutely impossible, to obtain a very large supply of water from any one well. As regards, indeed, the main question of obtaining from the sandstone an adequate supply of water, it is of the utmost consequence to establish indisputably that the sandstone is extremely permeable.

All the witnesses who have studied the structure of the formation on which Liverpool stands, concur in stating that it consists of a series of strata varying in permeability, and that large sheets of water may be conceived as spread out one above the other, being retained in their positions by intermediate beds more or less porous. Hence in sinking wells under ordinary circumstances, a gradual accession of water takes place as each succeeding stratum containing the sheets of water alluded to is intersected.

If this description of the structure represented truly the character of the sandstone, it is evident that wells would only affect each other when drawing water from the same series of strata; but there is a most important deviation from simple stratification in almost every part of the rock, from the existence of an infinite series of fissures, intersecting each other in every direction; a circumstance which obviously destroys the insulation between the sheets of water. These fissures are, by some, supposed to be filled with clay, and thus rendered impervious to water, which may be to some extent true; and it seems to be indicated by the circumstances already mentioned that wells in some cases are not found to act upon each other.

Dr. Buckland believes that some of these fissures are so extensive and so completely charged with clayey matters, as to divide the formation into a series of boxes. Mr. Rowlandson in his evidence dissents in a great measure from this view, and while admitting that fissures exist, he denies that they are quite impermeable, and to establish this, refers to the influence which one well exerts upon another. On this point he says, "I believe that those fractures are general, and in fact, that the water is diffused throughout the whole district through those cracks, and that therefore they are not filled with the impermeable clay." In this opinion I concur. Different degrees of porosity unquestionably exist, satisfactorily accounting in my mind for the different degrees of influence which wells are found to exert on each other. The facility with which the water will pass from one part of the sandstone to the other, depends principally on the size of the fissures, their character and their direction; and hence it is quite consistent with the existence of a very large number of fissures, that two wells at a great distance may affect each other while two that are near may show little or no connection.

The most extensive and the best established series of facts bearing on this part of the question are those surrounding Green Lane,

which were laid before me by Mr. Bold. I think no one can examine the instances he records, of wells at great distances being immediately drained by pumping at Green Lane, without being struck by the remarkable facility with which the influence of the pumping is transmitted. If the cases adduced had been few and partial, one might have hesitated in admitting such easy permeability as I believe to exist; but the sympathy here evinced is at once so extensive, and the evidence so authentic, as to free my mind from all doubt.

It was urged, that the instances alluded to by Mr. Bold were only from shallow wells, and that the effect would not have been produced if they had been deep ones; but these wells cannot be truly stated as *all* shallow, nearly one half of them being from twenty to thirty-nine yards deep. This, however, does not strike me as of much importance, for if in both cases the easy diffusion, or the migration of water from one part of the formation to the other be equally well established, it matters not whether the wells be shallow or deep.

My opinion is that, in considering the question of the supply of water, the rock may be looked upon as almost equally permeable in every direction, and the whole mass regarded as a reservoir up to a certain level, to which, whenever wells are sunk, water will always be obtained, more or less abundantly; and a very careful consideration of the facts that have come to my knowledge in the present investigation leads me to consider this view as the simplest and the only one capable of general application.

Quantity of Water to be got from Wells.

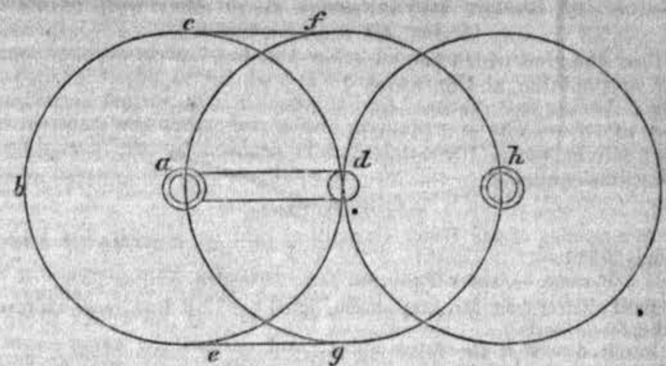
By thus recognising the permeability of the sandstone to a great extent, the question is relieved from many technical difficulties, which have caused much discussion without leading to any practical result. I shall, therefore, now assume that wells are sunk into that portion of the rock which is charged with water, and endeavour to ascertain what amount of water can be drawn from individual wells so circumstanced.

The effect of pumping from a well under such conditions will be to drain the adjacent rock, producing a comparative dryness on all sides, in such a manner as would be represented by an inverted cone; the bottom of the well being the apex of that cone, the sloping sides would represent the inclined surface of the water, flowing towards the well in all directions; and, as the pumping is continued, the sides of the cone will become more and more obtuse, or, in other words, more nearly horizontal, until an inclination is established where the friction of the water, in moving through the pores and fissures of the rock, is in equilibrium with the gravity upon the plane. And this condition of equilibrium once established, any further pumping power would be useless, as the water must gradually lower in the well until it is exhausted; and no additional power of pumping could then avail in increasing the quantity of water drawn from it.

The natural alternative under these circumstances is, to deepen the well by sinking a bore-hole, or to extend the filtering surface at its bottom by means of tunnels; and which of these methods is preferable has given rise to much difference of opinion. Where the pumping is periodical, the advantage of the tunnel or lodgment is unquestionably considerable, for it admits of the collection of a large body of water into these tunnels, as reservoirs, without causing much difference of level in the well itself; thus storing a quantity of water, in addition to what percolates gradually through the rock, which may be pumped out of the reservoirs, and with any rapidity.

Taking the view to be correct that the pumping from a well drains a conical mass of sandstone, until an equilibrium is established between the supply into the well and the draught from it, it would appear that the advantage of tunnelling is almost confined to its operation as a reservoir, for as the tunnel is extended it can only increase the drainage power of the well to the extent of a narrow band on each side of it, the slopes still corresponding with those of the side of the cone. Hence it is, I believe, demonstrable, that every attempt at increasing the yield of a well by tunnelling in the immediate vicinity of the well, can produce but limited permanent advantages.

In illustration of this, let us suppose that in the adjoining figure, a well is sunk at *a*, and that it drains an area represented by the circle *b c d e*, and that a tunnel is driven from *a* towards *d*, say one mile in length, and that another well is sunk at *d* upon the extremity or upon the terminus of this tunnel. The only effect of this would be to increase the drainage area of the well *a* by the area *f g h*, together with the small triangular spaces shown on the figure; whereas instead of the tunnel being driven from *a* to *d*, if the well at *d* had been sunk at *h*, the area drained would have been double that which was originally drained by *a*.



This method of looking upon the area drained by a well as represented on the surface by a circle is not strictly correct, because its form will be of course modified by the relative sizes, characters, and directions of the fissures through which the water finds its way to the well. The area represented by the circle in the figure will, therefore, most probably be very irregular in outline, but the way described by which the supply of water is transmitted to the well remains unchanged, and the conclusions to be derived from this reasoning may practically be depended on.

There is another defect in the system of tunnelling for the purpose of enlarging the supply of water at any great depth. Experience in Liverpool has clearly pointed out the necessity of, from time to time, deepening the wells in consequence of the increased demand upon them, and, with a system of tunnelling, the result would be similar, involving very great expense, and a most inconvenient operation. This inconvenience and expense has not hitherto operated with the public wells to any injurious extent, because the increase that has been made in them has not been considerable, but where we have to look forward to the utmost efforts being used to obtain the greatest possible supply of water from the sandstone at the fewest points, arrangements certainly ought to be contemplated for augmenting from time to time the supply at those points.

This view of the subject leads me to the opinion, that increasing the number of wells is likely to be a more permanent source of supply than extensive tunnelling, although the latter certainly admits of an easy mode of connecting the various sources of supply, and consequently of concentrating the whole of the pumping establishments.

Increase of Supply by Boring.

The other alternative for increasing the supply, namely, that of deepening the well, or of boring under it, has invariably been attended by an addition to the quantity of water yielded for at least some length of time; all the evidence which was given before me testifies that this may be safely reckoned upon. Let us now examine what would be the effect upon a well so deepened, with its increased amount of pumping.

It is clear that the space drained by the well before being deepened will now be increased in extent, and that an additional area will contribute water to the supply of the well; and this extension and consequent increase of the supply of water will proceed until the plane down which the water flows towards the well shall have attained nearly the same angle as was originally maintained by the shallower well—that is, the angle of equilibrium between the force of gravity and the friction in passing through the fissures. But the increase of supply to a well by deepening it, is by no means in proportion to the depth gained, as the supply is in all cases limited by the resistance which the water experiences in flowing towards the well through the fissures. It is, however, probable that a more permanent increase will be produced by deepening the wells than by constructing tunnels; a suggestion of course chiefly applicable to wells situated at a considerable distance from the River Mersey.

But all the public wells have already been sunk to the level of low-water mark, and from their proximity to the river it would, in my opinion, be inexpedient to increase the depth, either by sinking or boring, for if the sandstone be as pervious as I think it has been proved to be, a considerable amount of the supply to them would be derived from the river itself, and consequently the quality of the water much impaired.

There are numerous instances of wells having become brackish in the vicinity of the river; and, even at the distance of twelve

hundred yards, Mr. McGregor's well, from long continued pumping below low water, has thus become charged in a remarkable manner with sea salt, and there are many other well-known instances all tending to establish the fact, that when wells, especially if near the river, are pumped below the level of low-water mark, the permeability of the sandstone is such as to admit of impure water flowing into them. And this result is in perfect accordance with the views I have explained, and corroborates the statement of the mode in which the sandstone is drained by the pumping in individual wells.

The Bootle Works.

All these circumstances point out the impropriety of relying much, or even to any extent, upon an increase from deepening the existing public wells. To this remark Bootle may perhaps be made an exception, as the level of the water at the works there is so much above high-water mark, and cannot for some time be reduced to it; but their proximity to the river is such that any considerable deepening, accompanied by the abstraction of much larger quantities than at present, would even in them be likely to be attended by an influx of water from the river.

The Bootle Works furnish a very good example of the free communication through the sandstone by fissures or otherwise, from the circumstance of the water in a quarry at a distance of about half a mile being much influenced in level by the rate of pumping at the Water Works. The foreman (John Prescott) states distinctly that the Bootle Quarry maintained the level of water at about 54 feet from the surface from the time of its being opened until the engines at Bootle commenced working night and day, when the level of the water sank to 60 feet from the surface; and that when this rate of pumping ceased and the water was allowed to accumulate in the reservoir at Bootle, a corresponding rise took place in the level of the water in the quarry, and prevented the works proceeding in the manner deemed most eligible.

The Bootle Works also afford a very interesting and instructive lesson as to the effect of bore-holes, and clearly demonstrate that the increase of their number with very varying depths does not regulate the quantity of water to be obtained by their means.

In the reservoirs at these works there are 16 bore-holes, each of them having been made for the purpose of supplying an additional quantity of water. Their efficiency was thus tested. The reservoirs having been pumped dry and all the bore-holes tightly plugged, the supply to the reservoirs when in this condition was small, consisting only of some leakage through the bottom, and what came from the engine well. The plug was then removed from a bore-hole 308 feet deep, and the yield was ascertained to be at the rate of 921,192 gallons per 24 hours. A second bore-hole 599 feet deep was next unplugged and the yield increased to 949,464 gallons; and so in succession each of the remaining bore-holes was unplugged until the whole were opened. By referring to Table No. 7 in the Appendix the result of each step of the experiment will be found recorded, and it will be observed that the total increase by opening 15 bore-holes amounted only to about 112,792 gallons per 24 hours, being little more than an addition of one-tenth to the yield when only the first was unplugged. But the first experiment, showing a yield of 921,192 gallons, although important, is not entirely free from objection, arising out of the circumstance of the passage of water from the plugged bore-holes through fissures in the rock between them and the lodgment or the engine well.

It may be inferred from the evidence of Thomas German the engine-man at Bootle, that as each successive bore-hole was put down an increase of water was at first obtained, and the circumstances attending one or two of them would lead to the supposition of the supply being derived from independent fissures; they are now, however, all more nearly in a state of equilibrium, and in effect deriving their supply from one common source. If a pump were applied to the first of the bore-holes which was unplugged and the water drawn from it as quickly as it flowed, the yield of the neighbouring bore-holes would immediately almost cease, their contents being absorbed by the pump; or if the arrangement be changed, the same amount of pumping power distributed amongst the entire number of bore-holes, each would yield a quantity similar to that which flows into the lodgments under the ordinary course of working. Every addition to the pumping power would equally lower the level of the water in each bore-hole, and these results could only be modified by the lateral communications between the bore-holes not being uniformly permeable, but it is evident from the above experiment, where the flow was interfered with so little by the majority of the bore-holes being plugged, that great uniformity exists in these channels of communication.

This group of bore-holes at Bootle presents a complete epitome of what is actually going on upon a large scale throughout the town of Liverpool. The difference is only one of degree, consisting in the intervention of a large mass of rock between the wells, which offers more difficulty to the free passage of water from one to the other.

Source of Supply.

But, before referring more particularly to the wells in the town, or their influence upon each other, I may state my idea generally as to the source of the supply, and the mode of its distribution in the sandstone.

I conceive that the source from which all the strata and fissures in the sandstone become charged, is the rain falling upon the surface of the surrounding country; that so soon as they are fully charged the surplus overflows and is discharged into the adjoining brooks and rivers; and that the rain which falls upon the surface and finds its way into the fissures, passes through apertures or channels of limited area, and will consequently form an inclined plane towards the easiest outfall, the angle of this plane with the horizon varying slightly, according to the wetness of the season. This view is illustrated by the outfall along the margin of the River Mersey, of a number of springs deriving their supply from the inclined plane of water which rises towards the high ground of Everton and Edge Hill; and such is generally the state of things when wells are first sunk. In order that a well should yield a supply of water at all seasons, it must be carried below the extreme fluctuations of the angles described; and the effect produced upon the plane by sinking a number of wells below it, and extracting water from them, would be to form a series of indentations, varying in depth and extent, according to the intensity of the draught and the permeability of the strata.

These views are somewhat similar to those expressed by Mr. Newlands and Mr. Rowlandson, and are corroborated by the elaborate sections of wells furnished by the former gentleman representing their depths with the usual level of the water in them.

Periodic Influences.

It is now necessary to advert to the theory of Mr. Gage respecting certain periodic influences to which he ascribes the rise and fall of the level of the water in the wells. For the purpose of illustration, he has favoured me with a section which shows the highest and lowest levels of the water during each week, from January 1846, to June 1847, which are prepared with care, and exhibit well the facts they represent.

I cannot, however, arrive at the same conclusions with him.

The first section, referring to the Soho station, shows, from January to March 1846, a gradual elevation of the level of the water, and from March to June, a gradual depression. Following the section, we find that from June to August, there is a considerable rise, which is no doubt attributable to the bore-hole made about that period, and probably to the fact stated by Mr. M'Donald, that the pumping at this station was not then so continuous as before, owing to the Windsor engine being worked for more hours. From August 1846, to January 1847, this elevation is very steadily maintained, but then declines to the following May and June, indicating, perhaps, to some extent, the falling off of the first accession of water from the bore-hole, which is stated to have been in progress between August 1846, and May 1847.

The general contour of the section, after the boring, certainly affords no proof of the periodic rise in March, broached by Mr. Gage; and as he does not give the weekly quantities pumped from the well, there are no data to show that the undulation in the levels did not arise simply from the abstraction of varying quantities of water during the periods to which reference is made. If there be any such influence, it appears to me that it would operate entirely against his opinion of the chief supply of water to the sandstone being derived from beneath. But this subject, although of considerable interest in a philosophical point of view has not really any important practical bearing upon the question before us.

In order, however, to ascertain the fluctuation which the level of the water does undergo in the different wells, I have prepared and given in the Appendix, sections for the year 1849, exhibiting the greatest and least heights, with the important addition of the quantities pumped out each week; thus affording an opportunity of judging whether the variations at different seasons are not truly ascribable to this cause. The examination of these sections has perfectly convinced me that the levels of the water in the several

wells follow always an inverse ratio to the quantities of water abstracted. Taking the Soho station at the end of February, when the level was at the highest, it will be seen that the average weekly number of hours worked, for nine weeks equally distant from the end of February, amounted to $70\frac{1}{3}$, and the average quantity to 2,300,510 gallons, whereas in the following month of June, when the level was lowest, the average number of hours per week for nine weeks amounted to $139\frac{3}{4}$, and the average quantity to 4,160,884 gallons, a cause quite sufficient in itself to account for the level of the water in the well subsiding without having recourse to any more abstruse reasoning. At the Water-street station the average work for thirteen weeks, extending over March, April, and May, was 65 hours per week, and the average quantity pumped 2,552,095 gallons, while the average of ten weeks over part of July, August, and September, was 84 hours per week, and the average quantity pumped 3,084,129 gallons.

These sections are, in my opinion, very informing when thus accompanied by the weekly quantities pumped from the wells. They show that, when the draught is equal to the supply, the general contour remains horizontal; that when the draught is increased this line declines, and again becomes horizontal when the equilibrium has re-established itself; and that the lower level begins to ascend immediately the quantity abstracted becomes reduced. It is therefore evident that the cause of the alterations in level is chiefly to be ascribed to the abstraction of different quantities of water by pumping.

A careful study of the facts which have now been referred to and explained has led me to the following conclusions:—

That an abundance of water is stored up in the new red sandstone, and may be obtained by sinking shafts and driving tunnels about the level of low water.

That the sandstone is very pervious, admitting of deep wells drawing their supply from distances exceeding one mile.

That the permeability of the sandstone is occasionally interfered with by faults or fissures filled with argillaceous matter, sometimes rendering them partially or wholly water-tight.

That neither by sinking, tunnelling or boring can the yield of any well be very materially and permanently increased, except so far as the contributing area may be thereby enlarged.

That the contributing area to any given well is limited by the amount of friction experienced by the movement of the water through the fissures and pores of the sandstone. And

That there is little or no probability of obtaining permanently more than about 1,000,000 or 1,200,000 gallons a-day, and this only when not interfered with by other deep wells.

(To be continued.)

ON THE SEWAGE OF TOWNS.

At the last meeting of the Royal Agricultural Society of England, Col. Grey informed the Council that this important subject had, along with the general interest it had lately excited in the public mind, become a matter of interest and study to his Royal Highness Prince Albert, and that he was commanded by his Royal Highness to bring before the Council of the Society, for their consideration and inquiry, should they think the subject worthy of it, what had struck his Royal Highness as being a simple plan for effecting the object in view. Leaving it to more competent judges to decide whether the sewage should be used as a liquid manure, or solidified, upon which point his Royal Highness wished to give no opinion himself, he had confined his consideration to the latter mode of application, for two reasons, namely, that in the solid form—

1. It could be more easily transported;
2. It could be obtained at the least possible expense.

Colonel Grey then proceeded to describe the plan proposed by his Royal Highness, which was simply this:—to form a tank, with a perforated false bottom, upon which a filtering medium should be laid; and to admit at one end the sewage into the tank, *below* the false bottom, when, according to the principle of water regaining its own level, the sewage liquid would rise through the filtering bed to its original level in the tank, and provided the filtering medium had been of the proper nature, and of sufficient thickness, it would be thus freed from all mechanical impurity, and would pass off into the drain, at the other end of the tank, as clean and clear as spring water. This simple and effective plan was illustrated by drawings, showing the vertical and horizontal sections of the tank, and by a neatly constructed model of its external form and internal arrangements. It was also clearly shown by these sections, how the sewage matter could be let into the tank, or shut off, when necessary, in the simplest manner, by means of common valves; and with what facility such a filtering tank might be applied to every existing arrangement of sewers without requiring any alteration in their structure. The filtering medium having abstracted from the sewage all extraneous matter, would, in all probability, become the richest manure, and could, at any time, by stopping the supply of sewage, be taken out by a common labourer with a shovel, and carted or shipped to any place thought most desirable. The solid matter, too, held in suspension by the sewage, would probably form a very rich deposit at the bottom of the tank, of a substance approaching in its qualities to guano, and could be extracted by removing the false bottom, which rested on arches or vertical supporters over the sewage below it in the tank, and could be easily made to lift up or take out for the purpose of such extraction. Two tanks might easily be constructed together, so that one might continue in operation while the other was being emptied. The experiment might be tried at any house-drain in town or country; in fact, his Royal Highness had himself tried the operation on a small scale with apparent success; and while he thus suggested an important and extensive application of the hydrostatical principle involved in the plan proposed, he wished to lay no claim to originality in the adoption of that well-known law of fluid bodies by which they make an effort, proportionate to their displacement, to regain their original equilibrium. On that principle was founded as he was well aware, the upward-filtering apparatus used by the Thames water companies. His Royal Highness's great object was by the simplest possible means to attain a great end; to effect an essential sanitary improvement, and at the same time to create a new source of national wealth by the very means employed for the removal of a deadly nuisance, and the conversion of decomposing matter highly noxious to animal life into the most powerful nutriment for vegetation.

His Royal Highness, too, wished to offer no opinion on the details required to complete the plan proposed, or on the mode of carrying it out in the most effective manner. Supposing it to be right in principle, its advantages in an economical point of view could only, his Royal Highness conceived, be ascertained by practical experience; and it was on that account that he wished to submit it to the consideration of the Agricultural Society, who might be better able to carry out the necessary experiments. It would remain to be decided what is chemically or mechanically the best and what the cheapest substance for the filter; what the best and cheapest construction of the tank; how long the sewage will pass before the filter becomes choked; and how soon the filter could be sufficiently saturated to make it profitable as a manure. His Royal Highness had used as the filtering medium, the following substances:—

1. Charcoal:—admitted to be the most perfect filtering substance for drinking water, retaining effectually extraneous matters, and well known for its singular powers of purification. 2. Gypsum (plaster of Paris, or sulphate of lime):—recommended by agricultural chemists for fixing ammonia and other volatile substances, by the decomposition to which it becomes subject when exposed to the action of volatile alkali. 3. Clay:—in its burnt state, would act mechanically as a filtering bed; and in its unburnt state, on account of its aluminous salts, has also the property, like gypsum, of fixing ammonia, or of decomposing the ammoniacal and other alkaline salts present in manure: and in either state would be cheaply procured.

All these substances, his Royal Highness thought, would in themselves be highly useful as manures, independently of the purpose they would subserve as agents for filtration, or for the additional amount of manuring matter they would receive from the sewage which they purified. His Royal Highness, however, in thus incidentally referring to the substances he had himself employed for the filtering medium, was well aware how many more of equal, if not superior, value, would suggest themselves to others, who, like himself, felt an interest in effecting the important object proposed. As he had given no opinion on the general question of liquid or solid application of manure, but had merely stated the grounds of preference, in a practical sense, of the solid form over the liquid for the purposes of the filtering operation under consideration, his Royal Highness entered into no discussion of the amount of manuring matter retained by the filter compared with the soluble matter that might pass through it along with the water, and remain in that liquid in a soluble, colourless, and transparent form; nor of the value of such filtered water for agricultural purposes.

EXPERIMENTS ON CAST IRON.

A SERIES *of* EXPERIMENTS *on the* COMPARATIVE STRENGTH *of different Kinds of* CAST IRON, *in their simple state as cast from the Pig, and also in their compounded state as Mixtures; made under the directions of* ROBERT STEPHENSON, Esq., *with a view to the selection of the most suitable for the various purposes required in the construction of the High Level Bridge.*

The bars were all cast from the same model, and as near as possible one inch square. They were all weighted on the centre of their length by a machine made expressly for testing the same, having a fixed distance of bearing of exactly three feet.

The experiments were conducted at Gateshead Iron Works between the months of September 1846, and February 1847.

The bars were all cast as near as practicable one inch square, those which were found to be defective in this respect were rejected previous to testing. If, however, upon the breaking of the bars and measuring across the section of fracture, any difference from the true size was discovered, it was noted in the remarks. When the difference was not appreciable by measurement it is stated "rather full in size;" when it was, the dimensions are given as $1\frac{1}{32}$ square, $1\frac{1}{16}$ wide, by $1\frac{1}{32}$ deep, and when this occurs, the breaking weights are reduced to one inch square.

NOTE.—From this point +, whenever it occurs, the weighting was continued by small shot, 7 pounds at a time, run from a cup containing that weight, until the bar broke, when if any remained in the cup it was weighed back.—B indicates the breaking weight.

HOT-BLAST IRON.

I. *Scotch—Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Metal mild and open in the grain at the centre of the bar.	406	·265	
	518	·36	
	630	·44	
	686	·51	
	B 742		
2. Fracture more close than No. 1.....	406	·31	
	518	·39	
	630	·495	
	686	·535	
	+ 742	·59	
	B 779	·655	
3. Close and uniform.	406	·315	
	518	·41	
	630	·54	
	686	·61	
	+ 742	·65	·065
	B 804	·74	

Mean breaking weight of the three bars, 775 lb.

II. *Coltness, No. 3.—Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Metal clear and even in texture; open; rather dark in colour.	406	·325	·027
	518	·43	·046
	630	·56	·07
	658	·59	
	+ 686	·63	
	B 851	·82	
2. Metal as No. 1..................	406	·35	·04
	518	·475	·07
	630	·62	·10
	+ 658	·665	
	B 708	·74	
3. Metal as above. This bar exceeded the size by $\frac{1}{16}$ in depth.	406	·30	·02
	518	·395	·03
	630	·51	·052
	658	·54	
	686	·575	
	714	·607	
	+ 742	·645	
	B 809		

Mean breaking weight of the three bars, 789 lb.

III *Langloan, No. 3.—Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Dull grey fracture................	406	·33	·025
	518	·44	·04
	630	·575	·07
	B 728	·66	
2. Better fracture than No. 1. Soft open fluid iron.	406	·31	·015
	518	·415	·025
	630	·53	·05
	+ 686	·595	
	B 768	·71	
3. Ditto	406	·33	·035
	518	·43	·055
	630	·56	·075
	B 686	·63	

Mean breaking weight of the three bars, 727 lb.

IV. *Omoa, No. 3.—Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Close even fracture. Colour darkish blue.	406	·29	·02
	518	·38	·03
	630	·48	·05
	686	·54	
	742	·60	
	+ 798	·67	
	B 940	·845	
2. Ditto	406	·30	·022
	518	·39	·035
	630	·49	·047
	686	·545	
	742	·605	
	798	·675	
	+ 826	·71	
	B 938	·86	
3. Appearance of fracture as preceding bars, Nos. 1 and 2.	406	·28	·015
	518	·36	·025
	630	·455	·04
	686	·52	
	742	·575	
	798	·64	
	+ 826	·67	
	B 840	·78	

Mean breaking weight of the three bars, 906 lb.

V. *Omoa, No. 1.—Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Colour dark soft, open, grey iron..	406	·33	·02
	518	·44	·04
	630	·565	·066
	658	·60	
	+ 686	·63	
	B 771	·75	
2. Bar full in size; metal as No. 1	406	·32	·015
	518	·397	·025
	630	·505	·035
	658	·535	
	686	·565	
	714	·60	
	+ 742	·635	
	B 840	·76	

Mean breaking weight of the two bars, 805 lb.

VI. *Redsdale, No. 3.—Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Fracture clean; colour light grey; free, kindly looking iron.	406	·28	·017
	518	·375	·03
	630	·47	·05
	686	·525	
	742	·58	
	798	·64	
	+ 826	·67	
	B1043	·96	
2. Ditto	406	·265	·01
	518	·35	·02
	630	·435	·03
	686	·485	
	742	·535	
	+ 798	·595	
	B 943	·76	
3. This bar was $1\frac{1}{16}$ deep; the breaking weight is given as reduced to one inch.	406	·25	·012
	518	·325	·015
	630	·41	·02
	686	·45	
	742	·50	
	798	·555	
	826	·585	
	+ 854	·615	
	1124	·95	
	B 1056		

Mean breaking weight of the three bars, 1014 lb.

VII. *Redsdale. No. 1.—Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Clear fracture; colour dark; soft, open grain iron.	406	·305	·025
	518	·405	·055
	630	·52	·072
	686	·60	
	742	·66	
	+ 770	·70	
	B 795	·725	
2. Ditto, as No. 1 bar	406	·317	·035
	518	·425	·065
	630	·545	·095
	686	·615	
	742	·69	
	B 809	·775	
3. Ditto, as Nos. 1 and 2	406	·315	·03
	518	·415	·05
	630	·54	·07
	686	·61	
	742	·685	
	+ 770	·725	
	B 777	·735	

Mean breaking weight of the three bars, 794 lb.

VIII. *Redsdale, No. 1.—Hot Blast. Bars cast from metal sent purposely for testing.*

	Weight applied in lbs.	Deflection.	Set.
1. Light grey colour; rather open in middle.	406	.32	·025
	518	·42	·04
	630	·54	·07
	+ 686	·61	
	B 934	·97	
2. Open clear metal, like to No. 1 bar..	406	·315	·03
	518	·425	·06
	630	·565	·07
	686	·635	·085
	742	·705	
	798	·78	
	B 826	·83	
3. This bar was $1\frac{1}{32}$ square; the metal of a clear bright fracture, like to the two preceding bars	406	·325	·03
	518	·425	·045
	630	·54	·065
	686	·605	·075
	742	·675	
	798	·75	
	+ 826	·79	
	B 996	·102	

Mean breaking weight of the three bars, 919 lb.

IX. *Tow-Law, No. 3.—Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Broke; short iron; light grey colour; mild and clear.	406	·35	·03
	518	·485	·06
	630	·645	·095
	B 686	·70	
2. Clear, good appearance, but evidently tender iron.	406	·37	·03
	518	·495	·045
	630	·585	·07
	+ 686	·715	
	B 731	·775	

Mean breaking weight of the two bars, 708 lb.

Average breaking weight of the preceding 25 bars, cast from nine sorts of hot-blast iron . . . . 826 lb.
Average ultimate deflection from 23 of the bars . . . . . ·789 in.
Average permanent set acquired in 22 of the bars from a weight of 630 lb. . . . . ·066

COLD-BLAST IRON.

I. *Staffordshire, No. 3.—Cold Blast. (Number doubtful.)*

	Weight applied in lbs.	Deflection.	Set.
1. Colour dark; iron soft and open for No. 3 iron.	406	·305	·02
	518	·40	·035
	630	·51	·05
	686	·57	
	742	·64	
	+ 770	·675	
	B 867	·79	
2. Not quite so dark colour as No. 1 bar. Bar rather full in size.	406	·285	·015
	518	·37	·03
	630	·465	·035
	742	·59	
	770	·62	
	+ 798	·655	
	B 955	·85	
3. Similar fracture to No. 2 bar. Slight defect on bottom side.	406	·32	·02
	518	·42	·035
	630	·53	·065
	686	·59	
	742	·66	
	770	·70	
	B 798	·73	

Mean breaking weight of the three bars, 873 lb.

II. *Crawshay Welsh iron, No. 1.—Cold Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Clear bright fracture; metal open and free.	406	·295	·025
	518	·385	·045
	630	·49	·05
	686	·55	
	742	·62	
	+ 770	·655	
	B 900	·82	
2. Ditto, as No. 1 bar	406	·32	·025
	518	·42	·045
	630	·53	·06
	686	·60	
	742	·665	
	+ 770	·70	
	B 845	·81	
3. Bar slightly full in size; metal as in the preceding bars.	406	·275	·012
	518	·36	·03
	630	·465	·05
	686	·525	
	+ 714	·56	
	B 874	·77	

Mean breaking weight of the three bars, 873 lb.

III. *Blaenavon, No. 1.—Cold Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Colour dark grey; open free iron ..	406	·34	·035
	518	·46	·055
	630	·62	·095
	686	·715	
	B 742	·79	
2. Ditto as No. 1 bar................	406	·35	·037
	518	·465	·06
	630	·607	·105
	+ 686	·705	
	B 806	·91	
3 Ditto as No. 1 and 2 bars. Slight defect on under side.	406	·36	·045
	518	·485	·06
	630	·65	·11
	686	·735	
	B 714	·78	

Mean breaking weight of the three bars, 754 lb.

IV. *Coalbrook Vale, No. 1.—Cold Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Close dull fracture; defect in under-side. Bar snapped suddenly.	406	·325	·012
	518	·42	·015
	630	·52	·03
	742	·635	
	B 784		
2. Clearer fracture than No. 1 iron; rather close for No. 1 quality.	406	·285	·015
	518	·38	·02
	630	·48	·03
	742	·58	
	+ 770	·61	
	B 905	·76	
3. Similar fracture to No. 2 bar; slight defect in upper side. Rather full in size.	406	·28	·015
	518	·37	·02
	630	·455	·025
	742	·555	
	+ 798	·615	
	B 938	·76	

Mean breaking weight of the three bars, 876 lb.

V. *Coalbrook Vale, No.* 3.—*Cold Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Light colour; close iron; slight defect on upper side. Bar rather full in size.	406	·30	·01
	518	·385	·015
	630	·48	·022
	742	·595	
	+ 798	·655	
	B 910	·77	
2. Fracture same in colour and appearance as No. 1 bar.	406	·285	·015
	518	·37	·017
	630	·455	·017
	742	·56	
	+ 798	·62	
	B 948	·775	
3. Similar fracture to No. 1 and 2 bars.	406	·28	·015
	518	·365	·025
	630	·455	·03
	742	·56	
	798	·62	
	+ 826	·65	
	B 833	·66	

Mean breaking weight of the three bars, 897 lb.

Average breaking weight of the preceding 15 bars, cast from five sorts of cold-blast iron . . . . 855 lb.
Average ultimate deflection from 14 of the bars . . . . ·784 in.
Average permanent set acquired from 15 of the bars, with a weight of 630 lb. . . . . ·051

MIXTURES OF IRONS.

Ystalyfera, No. 3.—*Hot Blast. Anthracite. These bars do not rightly come under the head of mixtures, but are placed here from their peculiarity as being Anthracite iron.*

	Weight applied in lbs.	Deflection.	Set.
1. Metal close, of even texture. Colour silvery grey.	406	·235	
	518	·265	
	630	·335	
	686	·43	
	+742	·48	
	B 877	·67	
2. Metal very close, fracture even. Colour silvery grey, as above.	406	·265	·000
	518	·345	·005
	630	·42	·005
	686	·465	
	742	·515	
	770	·53	
	+798	·57	
	B 1008	·77	
3. Metal as the preceding bars, in colour and appearance of fracture.	406	·265	·01
	518	·345	·01
	630	·425	·015
	686	·48	·025
	742	·535	·04
	770	·56	·04
	798	·595	·05
	+826	·62	·055
	B 998	·815	
4. Metal as above..................	406	·28	·015
	518	·37	·02
	630	·455	·02
	742	·55	·03
	798	·61	
	+326	·64	
	B 1036	·85	
5. Ditto as above..................	406	·25	·01
	518	·325	·017
	630	·407	·02
	686	·45	·025
	742	·495	·03
	798	·555	
	826	·575	
	+854	·60	·075
	B 1041	·79	
6. This bar being cast large, was filed on the sides to exactly one square inch, with a view to ascertain if the outer skin or crust was advantageous as to strength.	406	·255	·01
	518	·34	·025
	630	·415	·025
	686	·46	·035
	742	·515	
	798	·565	
	+854	·62	
	B 1026	·81	

Mean breaking weight of the six bars, 998 lb.

I. { *Ystalyfera, No.* 3.—*Anthracite* / *Blaenavon, No.* 1.—*Cold Blast* } *in equal proportions.*

	Weight applied in lbs.	Deflection.	Set.
1. Fracture uniform darkish grey; rather open.	406	·285	
	518	·375	
	630	·47	·03
	686	·535	
	+742	·605	
	B 892	·83	
2. Clear uniform fracture; rather closer than No. 1 bar.	406	·26	
	518	·35	
	630	·415	
	686	·51	
	742	·57	
	+798	·65	
	B 925	·84	
3. Clear iron; rather open, bluish grey	406	·325	·03
	518	·415	·05
	630	·54	·08
	686	·61	
	+742	·645	
	B 812	·80	

Mean breaking weight of the three bars, 876 lb.

II. { *Garscube, No.* 1.—*Hot Blast* / *Redsdale, No.* 3.—*Hot Blast* } *in equal proportions.*

(*No.* 1 *Cast of bars.*)

	Weight applied in lbs.	Deflection.	Set.
1. Close grained, rather dark in colour.	406	·27	
	518	·335	·02
	630	·44	·035
	686	·49	
	+742	·55	·06
	B 991	·84	
2. Similar to No. 1 bar	406	·275	
	518	·365	
	630	·465	
	686	·52	
	742	·575	
	798	·635	
	+826	·68	
	B 971	·87	

Mean breaking weight of the two bars, 981 lb.

III. { *Garscube, No.* 1.—*Hot Blast* / *Redsdale, No.* 3.—*Hot Blast* } *in equal proportions.*

(*No.* 2 *Cast of bars.*)

	Weight applied in lbs.	Deflection.	Set.
1. Metal soft and open at centre of bar. Cast at an angle of 15°.	406	·305	·01
	518	·39	·025
	630	·495	
	686	·55	
	742	·61	
	+798	·675	
	B 812	·69	
2 More close than No. 1 bar. Cast at an angle of 15°.	406	·28	·015
	518	·37	·03
	630	·465	
	686	·52	
	742	·585	
	+798	·64	
	B 1000	·89	
3. Fracture like to No. 1 bar. Cast at an angle of 20°.	406	·28	·01
	518	·38	·015
	630	·485	
	686	·55	
	742	·615	
	+798	·675	
	B 910	·825	

Mean breaking weight of the three bars, 907 lb.

IV. { *Dundyvan, No.* 3.—*Hot Blast.* / *Coltness, No.* 3.—*Hot Blast.* } *in equal proportions.*

	Weight applied in lbs.	Deflection.	Set.
1. Mild open metal	406	·29	
	518	·385	
	630	·49	
	686	·55	
	742	·61	
	+770	·655	
	B 833	·725	

	Weight applied in lbs.	Deflection.	Set.
2. As No. 1 bar	406	·30	·015
	518	·395	·03
	630	·49	
	683	·545	
	742	·61	
	+770	·64	
	B 860	·74	
3. Clear good fracture, but evidently wants tenacity, from its breaking with so little deflection.	406	·325	·03
	518	·425	·04
	630	·53	
	658	·565	
	+686	·59	
	B 779	·68	

Mean breaking weight of the three bars, 824 lb.

V. { *Redsdale, No. 1.—Hot Blast*; *Clyde, No. 3.—Hot Blast*; *Coltness, No. 3.—Hot Blast* } *in equal proportions.*

	Weight applied in lbs.	Deflection.	Set.
1. Fracture clear and even; metal mild	406	·275	
	518	·375	
	630	·485	
	686	·55	
	742	·625	
	770	·675	
	+798	·705	
	B 876	·80	
2. Clear grey; metal rather open at centre of bar.	406	·315	·025
	518	·415	·05
	630	·53	
	686	·60	
	742	·67	
	+770	·71	
	B 887	·88	
3. Metal as No. 2 bar	406	·325	·02
	518	·425	·03
	630	·55	
	686	·625	
	714	·665	
	742	·70	
	+770	·73	
	B 815	·80	

Mean breaking weight of the three bars, 859 lb.

VI. { *Langloan, No. 3.—Hot Blast*; *Omoa, No. 1.—Hot Blast*; *Forth, No. 3.—Hot Blast* } *in equal proportions.*

	Weight applied in lbs.	Deflection.	Set.
1. Dark bluish grey; rather soft. Bar slightly defective on upper side.	406	·32	·025
	518	·425	·04
	630	·55	
	686	·62	
	714	·66	
	+742	·70	
	B 817	·805	
2. Metal as No. 1 bar	406	·33	·03
	518	·45	·045
	630	·58	
	686	·665	
	714	·70	
	+742	·74	
	B 847	·91	
3. Metal as No. 1 and 2 bars; dark in colour, and soft.	406	·32	·02
	518	·43	·035
	630	·56	
	686	·635	
	714	·675	
	+742	·715	
	B 824	·83	

Mean breaking weight of the three bars, 829 lb.

VII. *Omoa, Blair, Clyde, Langloan, Forth, and Coltness, all No. 3.—Hot Blast, in equal proportions.*

	Weight applied in lbs.	Deflection.	Set.
1. Fracture clear; would indicate good iron.	406	·27	
	518	·37	
	630	·47	
	686	·53	
	742	·59	
	B 798		
2. Fracture like to No. 1 bar	406	·265	
	518	·36	
	630	·45	
	686	·51	
	742	·56	
	+770	·62	
	B 965	·83	
3. Clear, uniform and close; rather dark.	406	·3	·015
	518	·39	·025
	630	·485	·03
	742	·61	
	+798	·675	
	B 940	·84	

Mean breaking weight of the three bars, 901 lb.

VIII. *Scotch Hot Blast and Scrap. ordinary Foundry Mixture, for general purposes.*

	Weight applied in lbs.	Deflection.	Set.
1. Metal close; dull grey	406	·295	·015
	518	·375	·025
	630	·48	·037
	686	·54	·045
	742	·60	
	B 798	·665	
2. Fracture brighter than No. 1 bar	406	·295	·02
	518	·385	·026
	630	·49	·045
	686	·545	·052
	732	·605	
	+770	·635	
	B 909	·80	
3. Close and like to No. 2 bar. Bar full in size by nearly $\frac{1}{16}$ in depth.	406	·285	·015
	518	·37	·02
	630	·465	·035
	686	·525	·045
	742	·585	
	770	·61	
	+798	·64	
	B 929	·78	

Mean breaking weight of the three bars, 879 lb..

IX. { *Carnbroe, No. 1.—Hot Blast*; *Redsdale, No. 3.—Hot Blast* } *in equal proportions.*

	Weight applied in lbs.	Deflection.	Set.
1. Clear open; light colour	406	·31	·017
	518	·40	·017
	630	·50	·025
	686	·56	
	B 714	·595	
2. As No. 1 bar. Lighter colour than than the Coltness and Langloan bars.	406	·30	·02
	518	·39	·025
	630	·49	·04
	+686	·545	
	B 720	·59	

Mean breaking weight of the two bars, 717 lb.

X. *Same iron as No. 9, with an addition of one-third of Scrap iron. (The Scrap would be principally Cold Blast.)*

	Weight applied in lbs.	Deflection.	Set.
1. Metal free to work. Fracture clear and bright.	406	·265	
	518	·355	
	630	·44	
	686	·49	
	742	·545	
	770	·585	
	+798	·605	
	B 826	·64	
2. As No. 1 bar	406	·25	
	518	·33	
	630	·415	
	686	·46	
	742	·52	
	770	·545	
	+798	·57	
	B 920	·685	
3. As No. 1 and 2 bars	406	·27	
	518	·35	
	630	·435	
	686	·49	
	742	·54	
	770	·57	
	+798	·59	
	B 933	·73	

Mean breaking weight of the three bars, 893 lb.

XI. { *Crawshay (Welsh)* No. 1—*Cold Blast* / *Coalbrook-dale,* No. 1—*Cold Blast* } *in equal proportions.*

	Weight applied in lbs.	Deflection.	Set.
1. Grey; free open metal	406	·3	
	518	·39	
	630	·50	
	686	·58	
	742	·65	
	+770	·71	
	B 937	·96	
2. Metal dark-bluish grey; soft and open at centre of bar.	406	·33	·04
	518	·44	·05
	630	·58	·08
	686	·66	
	+714	·70	
	B 766	·775	
3. Metal as No. 2 bar	406	·31	·02
	518	·415	·03
	630	·55	
	686	·62	
	714	·665	
	+742	·71	
	B 880	·92	
4. As preceding bars, dark and open	406	·34	·03
	518	·45	·05
	630	·585	
	686	·67	
	+714	·715	
	B 837	·92	

Mean breaking weight of the four bars, 855 lb.

XII. *The Scrap iron used was principally old mill castings, such as shafts, hammers, rolls, &c., chiefly of Welsh Cold-blast iron.*

Ystalyfera, No. 3—Anthracite	40 parts	Mixture of iron selected for casting the arch ribs of the High Level Bridge.
Redsdale, No. 3—Hot Blast	40 „	
Crawshay, No. 1, Cold Blast	40 „	
Blaenavon, No. 1—Cold Blast	30 „	
Coalbrook-dale, No. 1—Cold Blast	30 „	
Scrap, selected (clean)	30 „	

FIRST CAST.

1. Defective near the centre of bearing, thus:

(Half size), short of metal in casting.

	Weight applied in lbs.	Deflection.	Set.
1.	406	·25	·012
	518	·345	·015
	630	·425	·03
	686	·48	·042
	742	·535	·05
	798	·58	
	826	·61	
	B 854	·65	
2. Defective in like manner to No. 1 bar. Metal clear, close grained, and even.	406	·28	·012
	518	·37	·017
	630	·45	·003
	686	·496	·004
	742	·545	
	798	·605	
	+826	·635	
	B 886	·70	

Mean breaking weight of the two bars, 870 lb.

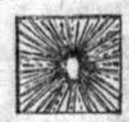
SECOND CAST.

	Weight applied in lbs.	Deflection.	Set.
1. Colour dullish grey. Fracture close and even.	406	·25	·005
	518	·32	·015
	630	·402	·025
	686	·45	·035
	742	·50	·045
	770	·525	
	798	·55	
	+826	·575	
	B 1043	·80	
2. Light silvery grey colour; close grained and uniform. Bar full in size, $1\frac{1}{16}$ wide by $1\frac{1}{32}$ deep. Breaking weight, 1060, reduced to one inch square.	406	·24	·005
	518	·315	·015
	630	·387	·02
	686	·43	·03
	742	·48	·04
	798	·525	
	826	·547	
	854	·575	
	+882	·60	
	1198	·965	
3. Fracture as No. 2 bar, in colour, &c. Bar full in size, $1\frac{1}{16}$ wide by 1 deep. Breaking weight, 1072, reduced to inch square.	406	·24	·005
	518	·31	·01
	630	·39	·02
	686	·435	·025
	742	·48	·003
	798	·535	
	826	·555	
	854	·59	
	882	·615	
	+910	·64	
	1144	·915	

Mean breaking weight of the three bars, 1058 lb.

XIII. *Second melting, from the metal of a defective rib-piece, without any addition of new "pig."*

1. White metal; fracture crystalline;" very hard; and radiating thus:—



Weight applied in lbs.	Deflection.	Set.
406	·195	·00
B 518	·25	·00
406	·203	·00
518	·255	·00
532	·265	·00
B 546	·27	·00
406	·215	·00
B 518	·27	·00

XIV. *Metal same as No. 12 selected for the bridge ribs. (Bars cast by Abbot and Co.)*

CAST FROM THE CUPOLA.

	Weight applied in lbs.	Deflection.	Set.
1. Bar very defective on top side. Metal dull, grey, close, and uniform.	406	·29	·015
	518	·375	·025
	630	·47	·03
	686	·53	·045
	742	·59	
	798	·65	
	826	·685	
	+854	·72	
	B 884	·76	
2. Iron close and uniform, of a dull light grey colour.	406	·29	·02
	518	·37	·025
	630	·475	·032
	686	·535	·64
	742	·595	
	798	·66	
	826	·695	
	+854	·73	
	B 928	·84	

Mean breaking weight of the two bars, 906 lb.

CAST FROM THE AIR FURNACE.

	Weight applied in lbs.	Deflection.	Set.
1. Iron very similar in colour and appearance to the two preceding bars.	406	·28	·02
	518	·365	·025
	630	·465	·04
	686	·52	·05
	742	·575	
	798	·635	
	826	·67	
	+854	·70	
	B 1023	·94	
2. Bar very defective, or the result would have been very great.	406	·27	·015
	518	·355	·022
	630	·46	·035
	686	·52	·055
	742	·585	
	798	·65	
	826	·685	
	+854	·72	
	B 891	·77	

Mean breaking weight of the two bars, 957 lb.

XV. *Mixture for Railway Chairs.*

$\frac{1}{9}$*th part Crawshay, No. 1—Cold Blast.*
$\frac{1}{3}$*rd part Redsdale, No. 3—Hot Blast.*
$\frac{5}{9}$*th part Scotch, No. 1 and 3—Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Metal mild and open, of a dark bluish-grey. Slight defect on top of bar. Bar rather full in size.	406	·315	·025
	518	·42	·04
	630	·54	·065
	686	·62	·075
	742	·70	
	770	·74	
	+798	·795	
	B 835	·86	

	Weight applied in lbs.	Deflection.	Set.
2. Metal as No. 1 bar	406	·33	·03
	518	·45	·045
	630	·60	·085
	686	·69	·115
	742	·765	
	+770	·83	
	B 807	·91	
3. Metal shade lighter than No. 1 and 2 bars.	406	·295	·025
	518	·40	·05
	630	·53	·08
	686	·605	·10
	742	·685	
	770	·73	
	+798	·78	
	B 823	·84	

Mean breaking weight of the three bars, 822 lb.

XVI. *Mixture for Railway Chairs.*

$\frac{1}{6}$*th part Crawshay, No.* 1—*Cold Blast.*
$\frac{1}{2}$ *part Redsdale, No.* 3—*Hot Blast.*
$\frac{1}{3}$*rd part Scotch, No.* 1 *and* 3—*Hot Blast.*

1. Dark grey; uniform texture........	406	·27	·012
	518	·35	·02
	630	·435	·03
	686	·485	·04
	742	·54	
	798	·60	
	826	·625	
	+854	·655	
	B 951	·77	
2. Metal dull grey, as above; close and uniform.	406	·27	·017
	518	·36	·025
	630	·455	·035
	686	·51	·05
	742	·565	
	798	·625	
	826	·66	
	+854	·69	
	B 944	·80	
3. Metal as No. 1 and 2 bars	406	·295	·015
	518	·38	·035
	630	·48	·04
	686	·535	·05
	742	·595	
	798	·635	
	826	·665	
	854	·685	
	+882	·715	
	B 889	·72	

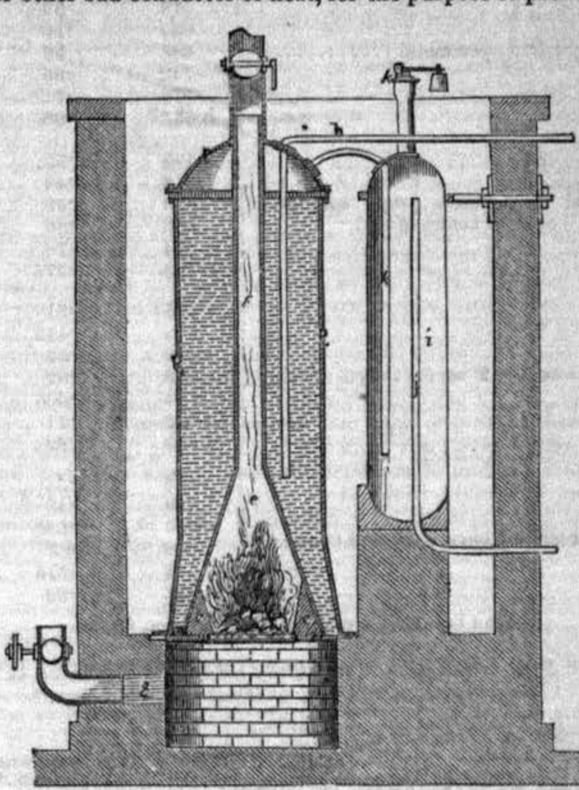
Mean breaking weight of the three bars, 928 lb.

REGISTER OF NEW PATENTS.

STEAM BOILERS.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for "*an invention of certain improvements in steam boilers.*" (A communication.)—Granted August 23, 1849; Enrolled February 23, 1850. [Reported in *Newton's London Journal.*]

The annexed engraving represents, in longitudinal vertical section, a boiler constructed according to the present invention; *a*, the fire-place; *b*, the fire-bars, surrounded by a wall of fire-bricks *c*, built upon a ledge or platform *p*, made of sheet or wrought-iron, and set in the masonry. The wall of fire-bricks thus forms a kind of shallow well, the bottom of which is formed by the fire-bars *b*. Fuel is supplied to the fire-place through an opening in front. The upper part *e*, of the fire-place, where the heat from the fuel is developed, is made conical, with an aperture at the top for the escape of the non-combustible gases up the flue *f*. The water of the boiler surrounds this conical fire-chamber and vertical flue; and the effect of this arrangement is, that the greater portion of the rays of heat, which radiate from the incandescent fuel, impinge against the sides of the cone, and are absorbed by the water which surrounds the same; while the rest are reflected back upon the fuel, and the heat in the fire-place is thereby very considerably increased; so that, as the combustible gases are evolved from the fuel, they are immediately consumed, instead of passing into the flue or chimney and escaping uselessly into the atmosphere. The conical chamber *e*, and the flue *f*, leading therefrom, the inventor prefers to construct of sheet copper,—that metal being a much better conductor of heat than iron. *g*, is the outer casing of the boiler, made of sheet-iron, and surrounded on all sides by a bed of sand, or other bad conductor of heat, for the purpose of preventing,



as far as possible, loss of caloric by radiation. The boiler is, by means of a supply-pipe *h*, kept nearly full of water, as shown; and the steam that is generated in the boiler passes therefrom through a pipe *k*, into the steam-chamber *i*, wherein any water that may come over with the steam will be deposited; and only dry steam will be allowed to pass from the upper part of the vessel *i*, down the steam-pipe *j*, to the engine. The steam-chamber *i*, is furnished with a safety-valve k^1, and the upper end of the flue or chimney *f*, is provided with a throttle-valve, for the purpose of regulating the draft. Air, to support combustion, is supplied by the pipe *l*, to the ash-pit, where it becomes warmed before it acts upon the fuel. When it is requisite to remove the conical chamber *e*, and copper flue *f*, and replace these parts by new ones, the top or cover g^1, of the boiler is first removed; the base of the cone *e*, is then detached from the cast-iron platform *p*, and the feeding aperture *d*, from the sides of the vessel *g*; after which, the flue *f*, and conical chamber *e*, are free to be lifted out, without deranging or displacing anything else, and a new chamber *e*, may be readily adapted to the boiler.

In order to set forth with clearness the nature of his improvements, the inventor makes the following observations on the principle of the generation of steam:—"It is based," he says, "upon the difference in density or temperature of two bodies—viz., the incandescent fuel and the water, which have always a tendency to balance themselves or maintain an equilibrium. Thus, in order to maintain a given expansive force of steam, certain conditions are necessary—viz., first, the combustion of a given quantity of fuel in the fire-place; second, a certain temperature of the fluids in the flue or chimney must be maintained, dependent of course upon the temperature required in the boiler; third, the metal, of which the inner parts *e*, and *f*, of the boiler are constructed, and which transmit the caloric from the fire to the water, must be one of the best conductors of heat, and be placed in a condition to conduct the heat as quickly as possible from the fire to the water; and fourth, the metal of which the outer part of the boiler is constructed should be preserved as much as possible from radiating or conducting away the caloric. The above conditions are necessary, because the volume of steam will correspond to the volume or quantity of fuel employed; and upon the temperature maintained in the chamber *e*, and chimney *f*, will depend the rapidity with

which heat will be transmitted and steam can be produced; the quicker and more powerful the transmission of caloric may be, the less extent of surface will be required: the pressure in the boiler will correspond with, or be in proportion to, the temperature of the water; and this pressure will increase or diminish as the temperature of the water increases or diminishes. Now, the rays of heat being divergent, and the temperature of the gases, which pass off by the orifice of the chimney, being in direct proportion to the intensity of the fire, or equal to that of the steam contained in the boiler, we may conclude that the heating surface of the chamber *e*, and flue *f*, is more than sufficient to take up and transmit the largest quantity of caloric which can be given out by the fire; and that the speed with which this heating surface transmits the caloric to the water is equal to the rapidity with which caloric is given off from the incandescent fuel; and further, that the practice of using the large extent of heating surface, which it has always hitherto been considered necessary to employ, in constructing steam-boilers or generators, is not derived from a principle or natural law, but merely from a rule laid down by constructors and engineers, and admitted *a priori*."

The patentee claims the combination, with a vertical flue, of a conical fire-place or enlarged heating chamber at the lower part of the same, or any mere modification thereof; whereby the intensity of the fire in the fire-place may be greatly increased by a portion of the caloric given out from the incandescent fuel being reflected back upon the fuel or combustible gases in the enlarged heating-chamber; and which fuel and combustible gases are thereby more effectually and economically consumed than in steam-boiler furnaces, with a more extended heating surface and less intensity of heat.

RAILWAY WHEELS.

ENOCH CHAMBERS, of Birmingham, smith, for "*improvements in the manufacture of wheels*."—Granted November 10, 1849; Enrolled May 10, 1850.

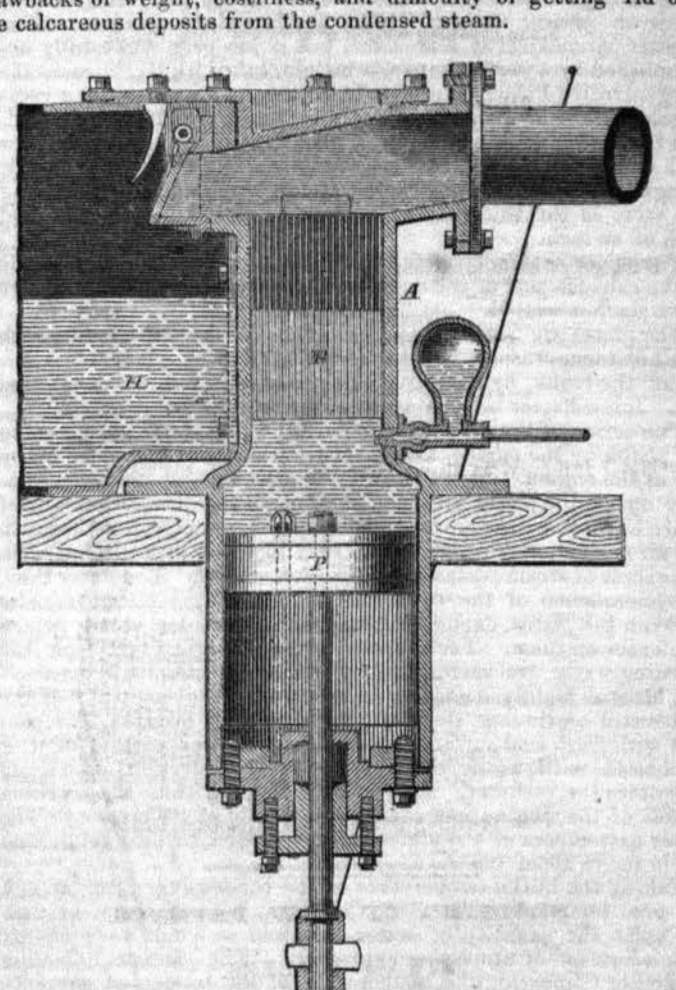
Wheels made according to this invention are each first made up into two halves, each half consisting of one half of the ring or felloe, one half the spokes, and one-half of the nave, all of wrought-iron, and the parts of a wheel are made in the following manner:—For each half of the nave a block or plate of iron is forged in a cylindrical exterior frame, with a flange or projection all round, and this flange or projection is to be drawn out by forging, so as to form projecting pieces at those parts in the circumference where the spokes are to be welded on. In the wheel shown in the drawings which accompany the specification there are eight spokes, four on each half-wheel, and in all cases this construction of wheel requires to have an even number of spokes, half being affixed or welded to one-half of the nave, and the other half of the spokes being fixed to the other half of the nave, and the spokes being placed in such relative positions that those of the one half shall come into the spaces between those of the other half. The projection or flange being thus drawn out or forged at intervals on each half of the nave of an intended wheel, so as to produce proper projections for the purpose of receiving the spokes; the spokes are to be welded on, each spoke having a portion of the ring or felloe of the wheel forged thereon, the alternate portions of the felloe or ring being on the two half naves respectively; so that when the two are brought together, and the inner surfaces of the two half naves are brought together, they will form the wheel. The two half naves are to be brought to a welding heat, and being placed one on the other in the position above described, are to be welded together by a suitable hammer or press. The patentee prefers to use a steam hammer for this purpose; and the parts of the felloe or ring of the wheel where they come together are also to be welded, and the tyre is to be shrunk on, and the wheel completed. The centre of the nave of the wheel is to be cut or turned out, and made suitable to receive the axle-tree, as shown, and as is well understood. Instead of welding the spokes and part of the felloe to the half naves before welding the half naves together, the spokes and parts of the felloe may be welded on afterwards, but the former method is preferred. In the preceding description special reference is had to railway wheels, but the same method of construction is equally applicable to wheels for common-road carriages and wagons.

Claims.—1. The manufacture of wheels by first making the nave in two parts (divided vertically) each having half the number of spokes, with a portion of the felloe attached to each spoke, and then welding together, the said two half naves, after which the tyre is shrunk on as usual.—2. The making of wrought iron naves with two flanges, each to receive, and have welded thereto, one half of the spokes of which a wheel is to be composed.

SIEMENS'S REGENERATIVE CONDENSER.

On Siemens's Patent Regenerative Condenser. By Mr. C. W. SIEMENS, of Birmingham. (Paper read at the Society of Arts, May 15th; Robert Stephenson, Esq., M.P., V.P., in the Chair.)

The paper commences with a historical sketch of the Condenser of the Steam-engine, from the invention of Savery, in which a single vessel served the triple purpose of steam-cylinder, condenser, and water-pump, to James Watt's injection condenser. Hornblower proposed a surface-condenser, which was, however, deficient in extent of cooling surface, and therefore failed, as have many others invented since; the most prominent being that of Mr. Samuel Hall, in which the steam was passed through tubes immersed in a stream of cold water. This condenser has the serious drawbacks of weight, costliness, and difficulty of getting rid of the calcareous deposits from the condensed steam.



Three years ago Mr. Siemens invented his surface-condenser for a situation where economy of space and material was essential. It consists of a number of copper plates $\frac{3}{32}$-inch in thickness, $4\frac{1}{2}$ inches broad, and 2 feet long, which are piled together with two longitudinal flattened wires of the same metal intervening between the adjacent plates, the whole pile being screwed up tight together between the sides of a rectangular cast-iron vessel, constituting the body of the condenser. The ends of the plates project through the top and bottom of the vessel, and are planed flush with its exterior surfaces. The joints are at top and bottom, secured by means of india-rubber rings, screwed down under small cast-iron frames, and which yield to the difference in expansion of the two metals. The flattened wires are laid parallel, and about three inches apart, and form, with the plates, a large number of narrow passages, through which the cold condensing water flows in an upward direction without entering the vacuous space of the condenser, into which the ends of the plates outside the flattened wires—forming the condensing surfaces—project. The heat of the steam is thus passed through the plates, from their edges towards the centre, to the condensing water,—the limit to its efficiency being the conducting power of the metal.

The essential features of this invention are its comparative cheapness of construction, the easy access it affords to the water-channels, and reduction in the quantity of condensing-water required. Its dimensions are as follows:—

Heat-absorbing surface by the the water	18 sq. feet per H.P.
Condensing surface	9 do. do.
Thickness of metal through which the heat is conducted	$1\frac{1}{4}$ inch.
Weight of copper	60 lb. per H.P.
Space occupied by plates	·4 cube feet per H.P.; or

$\frac{1}{16}$th part of the space occupied by the tubes in Hall's condenser.

Encouraged by the success of this condenser, Mr. Siemens has directed his attention to the achievement of a still more important object, which is to condense the steam in such a manner, that the *condensing water issues into the hot well at boiling heat*, and yet produces an *efficient vacuum* within the working cylinder. This appears paradoxical at first sight, yet it has been succesfully accomplished by a perfectly new principle, called by Mr. Siemens the 'Regenerative Principle of Condensation.' It consists of a rectangular trunk A, of cast-iron, the lower end of which is cylindrical, and contains a working piston P, which performs two strokes for each one of the engine. In the trunk is a set of copper plates B, upright and parallel to each other,—the intervening spaces being the same as the thickness of the plates, viz.—between $\frac{1}{12}$th and $\frac{1}{16}$th of an inch.

The upper extremity of the condenser communicates on one side to the exhaust-port of the engine, and on the other through a valve V, to the hot-well H.

The plates are fastened together by five or more thin bolts, with small distance-washers between each plate. There is a lid at the top of the trunk, by removing which the set of plates can be lifted out. Immediately below the plates the injection-pipe enters.

The action of the condenser is as follows:—Motion is given to the piston by the engine, causing it to effect two strokes for every one of the engine. At the moment that the exhaust-port of the engine opens, the plates are completely immersed in water, a little of which has entered the passage above the plates, and is, together with the air present, carried off by the rush of steam into the hot-well, the excess of steam escaping into the atmosphere. The water then, in consequence of the downward motion of the piston, recedes between the plates, exposing them gradually to the steam, which condenses on them. Their upper edges emerging first from the receding water are surrounded by steam of atmospheric pressure, and become rapidly heated to about 210°. The emersion of the plates still continuing, the steam is constantly brought into contact with fresh cool surface, by which the greater portion of it is condensed, until, as the piston descends, the injection enters and completes the vacuum. This is done by the time the working piston of the engine has accomplished $\frac{1}{4}$th of its stroke. The upper extremities of the plates become heated to near 210°, and the lower to about 160°.

Taking the initial temperature of the condensing water at 60°, the final temperature at 210°, the latent heat of steam at 212° 960 units, the quantity of water required is 6·6 lb. to condense 1 lb. of steam of atmospheric pressure. The common injection condenser (supposing the temperature of the condensed steam to be 110°) requires 21·2 lb. in place of 6·6 lb.

The advantages of this condenser are:—

1. Additional effective power gained on account of the vacuum = 30 per cent. taking the pressure of steam at 40 lb. above the atmosphere, and vacuum in the cylinder 12 lb.

2. Heat saved in generating steam by the use of boiling feed-water = 10 per cent. over the ordinary method of heating the feed-water to 110°, or 15 per cent. when no use is made of the condensed water for that purpose.

3. The steam which escapes uncondensed may be used to cause draught.

4. The displacing cylinder takes no motive power.

5. The condenser may be started and stopped at any time by turning the injection water on or off. If turned on, it at once forms the vacuum without involving the necessity of blowing through; and if turned off, it allows the engine to proceed as though it had not a condenser.

6. The air contained in the condenser is at each stroke completely expelled.

7. Greater compactness, and less expense, than the injection condenser.

Its dimensions in terms of parts of the engine are as follows:—Area of plate-chamber = three times that of exhaust-pipe; length of plates = $\frac{1}{8}$ that of stroke of engine; thickness of plates $\frac{1}{252}$ of their length; spaces between plates same as thickness, but never more than $\frac{1}{16}$th of an inch, as with that dimension no sediment can stand against the rush of water. Capacity of displacing cylinder = that of plate chamber.

It has been attempted to adapt this condenser to the locomotive; and of the advantages which would be gained if this could be done there can be no doubt. In this case the two condensers were cast in one piece, and placed directly in front of the cylinders. They differed from that just described only in the length of the condenser and stroke of the displacing piston being much shortened; so that the velocity of the water between the plates may not be too great; and in having a second set of discharge-valves of peculiar construction for allowing the uncondensed steam to pass freely into the funnel. The ordinary supply of feed-water not being by itself sufficient to maintain the vacuum, this condenser, if applied to locomotives, should only be worked at intervals, on inclines &c., where its assistance would be needed.

In its application to low-pressure engines, since the steam from the cylinder has not sufficient power to force the air and heated water from the condenser into the atmosphere, a communication is made between the exhaust-valve of the condenser and the lower end of the displacing cylinder, which, for convenience of arrangement, is here reversed, and which receives the charge of water and air when its piston is at the opposite end of it, and when it is therefore vacuous.

In this case the amount of injection-water is reduced in the proportion of three to one. Ten per cent. is saved by the feed-water being made boiling hot, a great quantity of boiling water being provided which cannot fail to be useful for many purposes.

The first Regenerative Condenser was applied to a sixteen horse-power high-pressure engine, at Saltby Works, near Birmingham, in September 1849, where it has been found to answer. One is now being erected at the Paper Works of Messrs. Easton and Amos, at Wandsworth, and will shortly be in action.

A drawing was exhibited, showing the condenser applied to a common high-pressure engine, in connexion with a variable expansion valve, acted on by a governor, which is a modification of Mr. Siemen's chronometric governor, the pendulum being superseded by an expanding fly-wheel.

The principle involved in the Regenerative Condenser is applicable to many useful purposes, the most remarkable of which are what Mr. Siemens proposes to call his Regenerative Evaporator for brine and other liquids, and the Regenerative Engine, which are now in course of construction at the works of Messrs Fox and Henderson, near Birmingham, to whose enterprise Mr. Siemens expresses himself as indebted for the carrying out of his several inventions.

After the reading of the paper, a discussion took place, chiefly as to the practicability of applying the condenser to locomotives, in which Mr. Scott Russell, Mr. Crampton, and the author took part. It was closed by the Chairman, who said that the circumstances of the locomotive were so peculiar, the requirements of the most perfect simplicity, and the freedom from any but the most necessary dead weight so absolute that he feared this could not be applied to it, even if, which he doubted, the condensation could take place rapidly enough where the cylinder was filled and emptied four times in one second. But the principle was new to him, and certainly ingenious, as were the other inventions of Mr. Siemens; and in its application to stationary engines he hoped and believed his ingenuity would meet its due reward.

ON THE CONSTRUCTION OF ARCHES WITH HOLLOW CAST-IRON VOUSSOIRS.

In the construction of cast-iron bridges, it has generally been the practice to form a framework by means of ribs stretching across the full span in one or more pieces, in the form of an arch or otherwise, which ribs are stiffened and kept steady by transverse beams, diagonal struts, and ties; thus adopting to a certain extent the system followed in the construction of many of the wooden framed bridges, previous to the introduction of iron in being wholly used for such works. This, no doubt, is a very excellent mode of construction; but it is considered that by adopting the system of stone bridges, and having the voussoirs formed of cast-iron and hollow, a cheaper and easier constructed bridge could be erected; while the principle is one which possesses many peculiar advantages, and admits of being applied not only to arches of small, but also to those of very large spans.

In the framed system the ribs, beams, &c., are generally very heavy, require much workmanship in their construction, are difficult to cast, and after good castings have been obtained are very liable to be damaged before being put in their places; thus causing the reconstruction of other castings, and consequently adding much to the expense, on account of the risk and delay. By the proposed system the castings become of an ordinary nature, require less workmanship, are easier constructed, very light and easily handled, and run less risk of being damaged; and even when a number of the voussoirs were damaged, the contingent expense would be very little compared to that arising from the loss caused by the damage of a large and massive beam. Such castings are consequently cheaper executed, the cost per ton for the same kind of castings being frequently not much more than one-half that of the other; besides, by a judicious arrangement and economy, no more, or at least very little additional, metal need be required by the proposed than by the framed system.

Both in ancient and modern times, hollow bricks have been used in the construction of arches, especially where lightness was required, and no great weight to be sustained; as these bricks were liable to be easily crushed. With cast-iron this is, however, not the case, it being to a very great extent incompressible, the crushing weight for a square inch of cast-iron being 140,000lb., while good stock bricks require only 12,000lb. to crush it, and in stone the crushing weight varies, according to the quality, from 3166lb. to 6250lb. per square inch. Since hollow bricks have been successfully employed, it is easy to conceive that hollow voussoirs formed of such a hard and incompressible material as cast-iron, may likewise successfully be employed, not only for arches of a small but also for those of a very large span.

It is now an established principle, that when the materials of which an arch is composed are hard enough to resist compression, and the abutments sufficiently strong to resist being crushed or forced aside, there is no particular limit to the extent to which, if properly constructed, the span may not be carried. Of course, no substance being incompressible, it follows that there must be a limit beyond which the arch would destroy itself, but that limit will be greater or less according to the hardness of the material employed in the construction. An arch constructed of granite is capable of being carried to a greater span than one of good freestone, and still more so than one of freestone of an inferior quality, or of brick not sufficiently fired. And following out the same principle with hollow cast-iron voussoirs, a still greater span could be accomplished than with any of these other materials.

Besides the advantage of cast-iron voussoirs, on account of its extreme hardness it possesses another advantage, that of lightness, these voussoirs being capable of being made sufficiently lighter than the same constructed of stone, and still retain sufficient strength to resist the required pressure. The weight of material in a cast-iron arch would be from $\frac{1}{4}$th to $\frac{1}{5}$th that of a stone one, supposing the depth of the voussoirs was made the same in each, which however would not always be necessary, as when constructed of iron less depth would be sufficient, on account of its extreme hardness, the weight being so considerably diminished, and the pressure being more uniform over the entire surface of the joint: the surface of castings being much smoother and evener than that of an arch stone, which except in very particular cases is generally only neatly hammer-dressed.

Again, in the framed system usually adopted, the pressure is thrown on a very small surface, which is not the case in the proposed system; likewise the use of malleable iron is entirely avoided, it being purely a cast-iron arch, every part of which contributes its due proportion of resistance; forming a firm and compact mass, and possessing all the advantages of a stone arch.

Taking into consideration these many advantages—namely, the extreme hardness of the material employed, the decrease of weight and the superiority of the joint compared to stone arches, and the large extent of bearing surface compared to that of the framed system, it is surely not unreasonable to say that an arch on this principle may not only be carried to a greater extent than any hitherto constructed of stone, but equally as far, and perhaps further, than any that have yet been constructed of iron on the framed system. In the Grosvenor-bridge, across the River Dee at Chester, a stone arch has been succesfully thrown over a span of 200 feet. And in the Southwark-bridge, across the Thames at London, which is formed of cast-iron on the framed principle, the centre arch is carried to the extent of 240 feet; but with hollow cast-iron voussoirs, an arch equal and even exceeding either of these spans may be executed with safety.

In the construction of an arch upon this principle, it is proposed to have a raised piece cast on the side of each voussoir, fitting into a corresponding hollow in the one adjoining. By this means the whole becomes more firmly joined together, forming, as it were, a series of joggles throughout the whole structure, and entirely preventing any tendency of the arch to rise at the haunches, or of any of the voussoirs to slide. This is a very important advantage, and one which, in an iron arch, can be easily obtained with little or no additional expense.

Fig. 1.—Transverse Section of Voussoir.

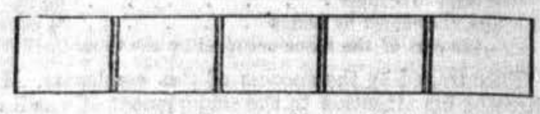


Fig. 2.—Transverse Section of Arch.

The form of the voussoirs may either be made similar to those in stone bridges, with the addition of these projections and hollows (see figs. 1, and 2), or, where additional strength is required, they may be executed according to fig. 3.

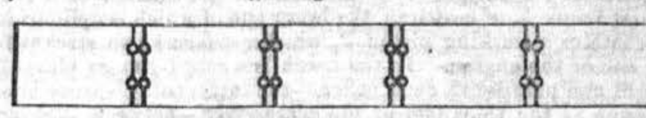


Fig. 3.—Transverse Section of Arch.

On account of the voussoirs being all firmly fixed to each other by means of the joggles already mentioned, it would not, on all occasions, be necesssary that they be placed close to each other at the ends, but kept a little separate, as shown in fig. 4. By this means, while the arch could still be made sufficiently strong, a considerable saving of material would be effected.

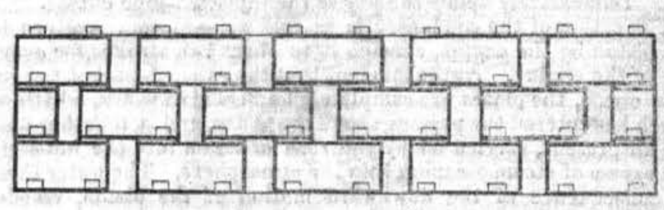


Fig. 4.—Plan of part Arch.

As to the thickness of metal required for small and medium spans, the average may be from $\frac{1}{4}$ to $\frac{3}{4}$-inch, and for large spans one inch would be sufficient for the average, care being taken that the ends of the voussoirs be made thicker than the sides. In order still further to strengthen the ends without requiring additional metal, the sides may be made slightly open.

In places where stone cannot be easily obtained, bridges could be constructed on this principle at a very moderate cost, while they at the same time would be both substantial and durable. The spandrils and abutments may be constructed of such materials as could be most readily obtained, and which was considered suitable; as such bridges admit of being finished similar to a stone one or otherwise, acording to the taste of the projectors and resources of the locality.

REVIEWS.

An Elementary Course of Geology, Mineralogy, and Physical Geography. By DAVID T. ANSTED, M.A. F.R.S. London: Van Voorst, 1850.

We are precluded from writing an article on Professor Ansted's new book, because on former occasions, prompted by him, we have gone over the whole subject of geology and engineering; and because he has so fully carried it out as to leave us no ground for cavil, and only the opportunity of expressing strongly our approval of the volume now before us. So far from being a mere reproduction of the Professor's former works, this is a complete manual of the several allied sciences, most carefully treated according to the last discoveries in the important domain of philosophy to which these newest offspring of science belong.

What was in the first instance a few pages has now become a regular section on practical geology and its application in engineering, and it has ceased to be a matter of question whether geology is an essential part of professional education.

As a trifling illustration of the intimate connection of geological facts with our pursuits, we give the following:—

"The whole quantity of water in the chalk of England north of the Wealden anticlinal must be enormously great, but is hardly calculable. At the very lowest conceivable estimate, considering the total area as 6000 square miles, the mean thickness only 300 feet, and only one-third of this fully saturated to the extent of one-fourth its volume, it would amount to twenty-five millions of millions of gallons; while the annual supply from rain to the extent of six inches of water absorbed per annum over an area of 2000 square miles, would amount to nearly 175,000,000,000, or more than $\frac{1}{150}$th part of the whole quantity of water contained. If the population of the chalk districts, including the whole area covered by London clay and gravel, be taken at 4,000,000 of individuals, and fifty gallons per day be allowed for each, a very large and sufficient quantity for all possible sanitary purposes, there will thus be needed only about 72,000,000,000 gallons per annum for this purpose, or not much more than a third of the estimated annual supply from rain, and only $\frac{1}{350}$th part of the quantity contained in the rock. It is unnecessary to state that only a part of this is directly available; but there must be a very large proportion that could be pumped out, although it may be a very different question as to how far this mode of obtaining water on a large scale is economical, or in other respects advisable.

"In the above estimate the quantities throughout are reduced to the very lowest that can be imagined, to show that the supply of water must be much greater than any demand that can arise. In point of fact, the proportion of rain entering the rock is more likely to be 12 inches than 6; the mean thickness of chalk might fairly have been taken at 600 feet instead of 300; and the quantity of water contained, instead of being taken at one-twelfth, may have been considered one-sixth of the bulk. Estimated in this way, the quantity of water in the chalk would be 100,000,000,000,000 gallons, and the annual supply 350,000,000,000. In addition to the quantity of rain, a large supply of water must enter some parts of the chalk from mere absorption from the atmosphere.

"The quality of water is unquestionably affected by the rocks through which it passes: although in this respect it is not always safe to conclude what the result will be without actual investigation. Thus water obtained from surface-deposits is almost sure to contain in solution some of those organic substances which in cultivated land must always abound, and which are always carried down to some little distance by the descending supply of rain; water from irony rocks, whether sand or otherwise, being generally chalybeate, and that from calcareous rocks holding carbonate and other salts of lime in solution. But when we examine the analyses of different rocks, as given in previous tables, there will be found also a number of other ingredients, as salts of soda, potash, magnesia, and other substances, and these will also be taken up, while the very action of water and the decompositions otherwise going on, produce sulphuric acid, and thus again act upon the containing rock, or alter combinations already in solution in the water. Thus it results, that in wells, however the water is obtained, there will be a certain proportion of saline and other ingredients, although the actual quantity may be less in amount and different in character in the case of deep and shallow wells in the same locality.

"It appears from a paper by Professor Brande, in the 'Quarterly Journal of the Chemical Society,' vol. ii. p. 345, that a well was sunk 426 feet deep, into 202 feet of chalk to supply the Mint. This well was completed 1st of January, 1847. The water rises to within 80 feet of the surface, and about 45,000 gallons per day are obtained; the level being then reduced by this amount of exhaustion to about 100 feet from the surface.

"Before the water was obtained from the chalk it yielded 44 grains of dry saline matter in the gallon of water. Since the well was finished the quantity is only 37·8 grains:—SG at 55°=1000·70."

On Mining there is very copious instruction, and from this part we take another illustration.

"Another fact to be considered by the practical miner, is that of the singularly frequent disturbances that have affected the beds of coal and the strata associated with them, and the remarkable complication of the *faults* that characterise many coal-fields. It must not be supposed that the effect of these disturbances is either uniformly advantageous or always disadvantageous to the immediate interests of the miner; but there cannot be the slightest doubt that we are indebted to such disturbances for frequent repetitions of the same bed of coal at the surface, when without them it would be so far covered up by newer deposits as to be utterly unattainable. If occasionally the miner, in prosecuting his labours, or the mine-owner in following what he considers a valuable seam of coal, is suddenly stopped by coming in contact with a fault, and finds the coal shifted several yards above or below, or even completely lost, he must not forget that it is perhaps owing to these very shifts that the outcrop has taken place at all in his neighbourhood, and that the coal is workable in the district in which he is interested.

"But there is another important advantage derived from the existence of these numerous faults in coal strata, namely, that they intersect large fields of coal in all directions, and by the clayey contents which fill up the cracks accompanying faults, become cofferdams, which prevent the body of water accumulated in one field from flowing into any opening which might be made in it from another. This separation of the coal-field into small areas, is also important in case of fire, for in this way the combustion is prevented from spreading widely, and destroying, as it would otherwise do, the whole of the seam ignited.

"An instance of the advantage resulting from the presence of a great line of fault, occurred in the year 1825, at Gosforth, near Newcastle, where a shaft was dug on the wet side of the great ninety-fathom dyke, which there intercepts the coal-field. The workings were immediately inundated with water, and it was found necessary to abandon them. Another shaft, however, was sunk on the other side of the dyke only a few yards from the former, and in this they descended nearly two hundred fathoms without any impediment from the water."

A Catechism of the Steam-Engine. By John Bourne, C.E. Third Edition. London: Longman, 1850.

We are glad to see the third edition of this work. We noticed it favourably on its first appearance, and it has since received several improvements.

Practical Ventilation, as applied to Public, Domestic, and Agricultural Structures. By Robert Scott Burn, Engineer. London and Edinburgh: Blackwood, 1850.

We had intended to notice this work at some length, for the subject is of practical importance, but unfortunately we are compelled to postpone this design until next month. In the meantime we may observe, that though the author has not announced any new doctrine, he appears to have collected very judiciously the opinions of Rumford, Tredgold, Arnott, Reid, and others, and to have put them in a shape suitable for the practical man.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

INSTITUTION OF CIVIL ENGINEERS.

April 30.—William Cubitt, Esq., President, in the Chair.

The paper read was "*On the Absorbent Power of Chalk, and its Water Contents, under different Geological conditions.*" By Professor D. T. Ansted.

After explaining the nature and extent of the chalk rock of England, both geologically and topographically, and briefly describing its chief physical peculiarities, the author proceeded to detail the results of some experiments made for the purpose of ascertaining the positive and relative absorbent powers of different kinds of chalk, when exposed to moisture under various circumstances.

The specimens experimented on were small cubes, each weighing from three to four ounces, taken from different districts and geological positions, in the upper, middle, and lower beds of the chalk.

From these experiments, it appeared, that the upper chalk, when it was to all appearance perfectly dry, contained about one-third part of a pint of water in each cube foot, which was never parted with under any conditions of dryness of the atmosphere; that in the case of an exposed surface of the rock, the absorption from a moist atmosphere would be unimportant, although when water was presented to it in a liquid form, the upper chalk was found capable of receiving into its mass a quantity of water amounting to more than two gallons for every cube foot of rock, beyond the quantity usually contained in apparently dry chalk, under ordinary exposure.

A specimen of the middle chalk, when thoroughly air-dried by six months' exposure, was found to contain about 23 parts water in 1000 parts; three-fourths of which water were readily given off by subsequent exposure to a perfectly dry atmosphere, very little more than the original quantity being re-absorbed on exposure to a saturated atmosphere; show-